S. HRG. 108–1026

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION'S (NASA) FISCAL YEAR 2005 BUDGET REQUEST

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

ONE HUNDRED EIGHTH CONGRESS

SECOND SESSION

APRIL 1, 2004

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ONE HUNDRED EIGHTH CONGRESS

SECOND SESSION

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CONTENTS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION'S (NASA) FISCAL YEAR 2005 BUDGET REQUEST

THURSDAY, APRIL 1, 2004

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Subcommittee met, pursuant to notice, at 9:30 a.m. in room SR–253, Russell Senate Office Building, Hon. Sam Brownback, Chairman of the Subcommittee, presiding.

OPENING STATEMENT OF HON. SAM BROWNBACK, U.S. SENATOR FROM KANSAS

Senator BROWNBACK. I'll call the hearing to order. Thank you all for joining us this afternoon. I'm pleased to welcome my friend, Sean O'Keefe, to testify for us today on the proposed NASA program and budget. It is a momentous year for NASA and for our Nation. On January 14, of this year, President Bush announced a new space vision, not just for NASA but for the Nation. It is a vision of an unlimited future for new generations of Americans, a vision of economic opportunity and human promise. Most of all, it's a vision of continued American leadership and destiny.

As I travel around my state of Kansas around this country and I speak to my colleagues in the Senate, many ask, why space and why now? I think the answer is simple. We cannot and will not leave our children a world where people of other nations are walking, building, and living on the moon, Mars, and elsewhere in the solar system and Americans are not there.

We cannot and will not cede the frontier to others. To do so would be the end of a vision begun over 200 years ago with the birth of our Nation. It is our destiny to lead the world in new frontiers, frontiers of freedom, opportunity, and exploration.

It is a real danger that we will lose the space frontier to others. A number of nations are planning or have already begun journeys deep into space. China recently moved up its launch date for its first lunar resource exploration and exploitation mission to 2006. India moved its robotic lunar program forward to 2007.

As an American, and a KU Jayhawk, I welcome competition, but make no mistake about it, these other nations are mounting ambitious missions to the moon and beyond for the very reasons that they promise opportunity and commercial success and they are the frontier. Can we afford to ignore this aspect? I think not. I plan a

specific hearing on this topic April 27 to consider what other nations are doing in space exploration. I do not want to cede that frontier to others. I will not cede that frontier to others.

We will hear today of NASA's impressive plans to move out with scientific, robotic, and human exploration and utilization of the solar system. These are impressive plans and ones I believe are not only affordable within current budget limitations, but that we can't afford not to do.

Mr. O'Keefe, I welcome you to the Committee. I want to congratulate you as well before I hand off to my other colleagues on the outstanding Mars rovers that are going and the pictures they are sending back, the electricity that they are generating about space exploration. It has been marvelous, and hats off to you and the team that's put that together and that continues to operate those in such a successful fashion.

I would like to issue a challenge. I'd like to see the United States mount robotic missions to the moon as early as possible, before others. I'd like to see us back to the moon with robotic missions within 2 years. Moreover, I'd like to see NASA try a new approach on this goal. Is there a possibility that we could challenge the private sector to do some of this or all of this for us and us contract with them, not as a managed government contractor, but as a service? We purchase for their success.

I'm also concerned over the future of the space shuttle, which we'll dedicate some time at this budget hearing about. The President's vision will require new, affordable access to space. The space shuttle is absorbing a huge amount of NASA's resources and will not fly for at least a year. I wonder if we shouldn't focus our energies on new, affordable access to space. We'll be holding a hearing on this May 5, and would like to consider if it might be time for national access to space commission to recommend a way ahead for all U.S. space access needs.

The reason I point this out in looking at it, and I've been talking with people here, people on the commission, is a space shuttle and the amount of funds that it consumes, is there a way—and I pose this as a question, not as some set position—but is there a way that we can move away from the shuttle much sooner and focus those resources on the moon, Mars, and beyond effort much quicker? Still being able to finish up the international space station, contracting for services, having others help us more in doing that. We're getting a lot of support from other places now. But so much of our budget is tied up in the space shuttle. Is there a way to move off of that sooner and transfer those resources into the moon, Mars, and beyond, and I really want to pose that as a question or thought.

I'll go down to my colleagues as they appear. Senator Breaux?

[The prepared statement of Senator Brownback follows:]

PREPARED STATEMENT OF HON. SAM BROWNBACK, U.S. SENATOR FROM KANSAS

I am pleased to welcome my friend Sean O'Keefe to testify before us today on the proposed NASA program. This is a momentous year for NASA—and for our Nation. On January 14 of this year President Bush announced a new space vision—not just for NASA but for our Nation. It is a vision of an unlimited future for new generations of Americans, a vision of economic opportunity and human promise. Most of all it is a vision of continued American leadership and destiny.

As I travel around my state of Kansas and as I speak to my colleagues in the Senate they all ask why space and why now. I think the answer is simple. We can not and will not leave our children a world where people of other nations are walking, building and living on the Moon, Mars and elsewhere in the solar system and Americans are not. We cannot and will not cede the frontier to others. To do so would be the end of a vision begun over two hundred years ago with the birth of our Nation. It is our destiny to lead the world on all new frontiers—frontiers of freedom, opportunity and exploration.

It is a real danger that we will lose the space frontier to others. A number of nations are planning or have already begun journeys deep into space. China recently moved up its launch date for its first lunar resource exploration and exploitation mission to 2006! India moved its robotic lunar program forward to 2007. As an American I welcome competition. But make no mistake about it—these other nations are mounting ambitious missions to the moon and beyond for the very reasons that they promise opportunity and commercial success. Can we afford to ignore this aspect? I think not and plan a specific hearing on April 27 to consider what other nations are doing in space exploration.

We will hear today of NASA's impressive plans to move out with scientific, robotic, and human exploration and utilization of the Solar System. These are impressive plans and ones I believe are not only affordable within current budget limitations—but that we can't afford not to do.

Now Mr. O'Keefe I'd like to issue you a challenge. I'd like to see the United States mount robotic missions to the Moon as early as possible—before others. I'd like to see us back to the moon with robotic missions within two years. Moreover, I'd like to see NASA try a new approach on this goal. Why not challenge the private sector to do this for us—not as a traditional contracted effort managed by the Government but as a service we purchase upon success?

I am also concerned over the future of the Space Shuttle. The President's vision will require new, affordable access to space. The Space Shuttle is absorbing a huge amount of NASA's resources and will not fly for at least a year. I wonder if we shouldn't focus our energies on new, affordable access to space. I plan a hearing May 5 on these issues and would like you to consider if it might be time for a national access to space commission to recommend a way ahead for all U.S. space access needs.

I look forward to your testimony and your answer to my challenge.

STATEMENT OF HON. JOHN BREAUX, U.S. SENATOR FROM LOUISIANA

Senator BREAUX. Thank you very much, Mr. Chairman, and Sean, thank you for being with us to give the Administration's recommendations on the budget and your request. I think this is an important hearing because budgets deal with the future and where we go from here and how do we get there from here. I have generally supported the administration's plan in dealing with a new vision for NASA, that we have to look at new alternatives in many areas, but also wanted to make very clear that I don't want to be relying on other countries' vehicles to get our men, women, and equipment back and forth to the space station.

I think it's obvious that for the near term and for the foreseeable future we're going to be relying on the continued use of the shuttle for a while. I mean, we talked about it one time, the great move toward an orbital space plane, which I thought was a great idea, but that's been shelved. So we're back to the drawing board on what's the next generation of vehicles to move men and women in outer space.

So I think that we can't take our minds off the fact that the Space Shuttle is a very functional piece of equipment, that it can carry tons and tons of equipment, 25 tons or more and a large number of crew members back and forth to the space station. That's very important and we're going to have to depend on it for

the foreseeable future. We don't want to fly until it's absolutely safe and I know that we made some decisions on that which need to be discussed, but I think that we're going to be relying on that old and dependable piece of equipment for a while, and we want to make sure it's as functional and as safe and as modern as it possible can be, and I would hope that we're requesting sufficient number of dollars to make sure that that continues into the near future.

Thank you. Thank you, Mr. Chairman.

[The prepared statement of Senator Hollings follows:]

PREPARED STATEMENT OF HON. JOHN BREAUX, U.S. SENATOR FROM LOUISIANA

The FY 2005 Budget Request is a very complex request, given the number of changes it proposes and the shifting of NASA's priority from emphasizing Exploration, Science, Advanced Space Transportation & Aeronautics to emphasizing Space Exploration as NASA's "highest priority." This alone is a complex change, and we are not sure we fully understand it.

After reviewing the budgetary "puts and takes," it seems as if NASA is making some very significant changes to its Science programs and, although there's nothing on the surface that indicates a shift of Aeronautics priorities, we wonder if that change won't occur as resources, too, as resources get tighter downstream.

And NASA is abandoning the Orbital Space Plane that would have given us a new means of transferring and rescuing astronaut crew to and from the International Space Station by 2008 and 2010, we understood, and is now going to "skip ahead" to a new program to transport crew to the Moon. Where this leaves us is a little unclear, since we also intend to keep sending crew and cargo to the Space Station for many years to come. How, and using what vehicles, is a little unclear, to say the least.

So one of the greatest concerns I have is how we're going to solve the Nation's Space Transportation problems. I'm surprised to say at this point that this budget doesn't make that clear, at all. We've had a decade of X vehicles and technology programs, spending billions of dollars, and now we don't even have a plan to replace the cargo-carrying capacity of the Space Shuttle nor to develop the Next Generation of launch vehicles.

Is there money for new lift vehicles in this budget? The NASA Budget Request is very unclear on that, and that can't be acceptable to the Congress or the space industry. Certainly industry can't be expected to pay the bill for these second generation technologies—we went down that road before and that didn't work.

Before this Congress is going to agree to end the Space Shuttle program, we will have to have better answers to these questions.

Senator BROWNBACK. Thank you very much and I have a statement from Senator Hollings that we'll submit for the record.

Senator Nelson.

STATEMENT OF HON. BILL NELSON, U.S. SENATOR FROM FLORIDA

Senator NELSON. Thank you, Mr. Chairman. Well, I support the President's request and if the word hasn't gotten to you about a statement that I made a couple of weeks ago, I want you to hear it directly from me. We almost lost your budget and the reason we almost did was the Budget Committee had marked up and cut NASA $631 million from the President's request—and because of that account in the budget act being a relatively small account, had that passed and if it were to have survived the conference committee on the budget, then the instructions back to the Appropriations Committee would have put NASA in an appropriations straitjacket, and we would not have been able to get anywhere close to the President's request.

Now, all throughout the Budget Committee deliberations, I could not get Senator Sessions, who also sits on the Budget Committee, the two of us, we could not get the White House team to come up and stand by their request. As the budget proceeded out of the Committee and up to the floor, only because Senator Shelby at one o'clock in the morning before we passed the budget at 1:15 a.m. told Chairman Nickles that he was going to vote against the budget resolution unless they restored NASA to the President's level, only until that NASA was going to be put into a situation of a $631 million cut. So I give full credit to Senator Shelby, Senator Sessions and I, were all three of us working it that night, but with a lack of effort on the part of the White House to let the members of the Senate know that this was a critical mark for them.

And so you know what the consequence of that would be, I know what the consequence of that would be. It would shelve a lot of the visionary plans that you have and of which we just can't take those risks. Now, in the meantime the House of Representatives have passed their budget, and they have whacked NASA's budget so we've got another opportunity to pull out all the stops when this goes to the conference and let it be clear that the President is firmly behind his request because of all these things that are going to be affected in the out years. And I would hope that you would help us convey that message back to the White House as we get ready for this.

Mr. Chairman, I'll just make the other parts of my comments in the form of questions.

Senator BROWNBACK. Thank you, and thanks for holding that back if you can because I want to get to Sean as quick as we can to get as much information and questions as soon as possible.

Senator Wyden?

STATEMENT OF HON. RON WYDEN,
U.S. SENATOR FROM OREGON

Senator WYDEN. Thank you, Mr. Chairman. I too want to welcome the Administrator. He's always been very forthcoming and responsive. I think Senator Nelson's comments sort of reflect how I want to approach this. He said that he supports the President's request, and I would like to support the President's request but I think that the Committee and the Senate and to a great extent, the country, are still in the dark until we can get some answers to this question you and I have talked about. That is the comparative merits and cost effectiveness or risk reward of manned versus unmanned space flights, and we have just got to get that report wrapped up that we've been talking about. I was under the impression we were going to have it done by February 18.

Your folks, to their credit, came to talk to us about it, but I just think, Mr. Administrator, we've got to figure out a way to get a sharp pencil to this and really lay out for the country what the alternatives are, because without it, when you look for examples and what's being discussed with respect to the prospect of dedicating $170 billion to returning humans to the moon between 2015 and 2020. That is a boatload of money and people are going to say, how do you justify the costs?

And so, particularly since we've got many already voicing concerns with respect to whether the agency's met the recommendations of the CAIB report, so we've got to figure out a way to get our arms around this issue. I'm going to be asking some questions about it. Most of my questions deal with the fact that until we get that report, we're sort of here in the Committee and I think in the Congress generally all trying to excavate this information piecemeal.

And I've really appreciated your willingness to take this on. I just think we've got to figure out a way to move this to completion and really get something that represents a document based on the best and most rigorous kinds of judgments with respect to cost benefit. What I think folks are doing now is they've got a lot of pictures and the pictures are good, but I think we've got to get into those kind of issues that you get to when you're making some hard calls with respect to cost benefit, and I'm anxious to work with you on that and get this done.

Thank you, Mr. Chairman.

Senator BROWNBACK. Thank you, Senator Wyden.

Senator Stevens?

Senator STEVENS. I have no opening statement.

Senator BROWNBACK. Thank you.

Senator Hutchison?

STATEMENT OF HON. KAY BAILEY HUTCHISON, U.S. SENATOR FROM TEXAS

Senator HUTCHISON. Thank you, Mr. Chairman. I just would say that I think that all of us have the goal of making sure that really the vision of the President is realized. I think he was very bold. We need to follow through on that.

I am concerned about reports of different people talking about phasing out the shuttle program sooner. It just seems to me if we are going to keep our international commitments to the space station, which the President has said we're going to do and which you have reiterated on many occasions and which I support, that we must also have the commitment to the Space Shuttle. We're not going to be able to get the payload up there and complete the station without our shuttles as well as the use of the Russian shuttles being maximized.

The shuttle can deliver as much as 25 tons of payload to orbit and bring back as much as 20 tons. It is the only vehicle that we have that is capable of that heavy lift. So I hope that we don't start saying, well, technical repairs are not going to be made, and then we sort of buy something that is very premature, very much in planning but not nearly into implementation phase and then get into a situation where we can't finish the station.

So I am very concerned about any kind of effort that would shortchange the shuttle, and I think we need to do it right, we need to finish the station, keep our international commitments, and then do the research that we have spent all this money getting prepared to do.

So thank you for being here. I will have to leave early, but I am very interested and will listen to your testimony and then be able to work with my colleagues to assure that we do this right.

Senator BROWNBACK. Thank you, Senator Hutchison. Now you realize we're all of one mind up here, Director O'Keefe, and we look forward to your presentation of the NASA budget.

STATEMENT OF HON. SEAN O'KEEFE, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. O'KEEFE. Thank you, Mr. Chairman. I appreciate the opportunity as well. Last year, on August 26, when the *Columbia* Accident Investigation Board called for the examination of a broader strategy and vision to be articulated by the President, we began the work some time before that in developing an inter-agency process that advised the President on a range of options that could be considered in pursuit of such a strategy, such a vision statement.

On January 14, he delivered that. It was the commentary offered by every oversight committee, by every conference that had been conducted over the last year that this was necessary and time for such an effort to be made, and that's precisely what he delivered on. And in that regard, the opportunity now, as several members have observed here, is the President's budget which supports that objective, very specifically starts us down the road to achieving that strategy and set of goals, has been endorsed in the Senate and we thank you for that support and initiative in that particular area of moving the Senate resolution forward in a way that does fully support the President's initiative.

As the conference continues on, yes, we're working diligently to assure that the Senate position is sustained as part of the resolution, to assure that the distinguished Chairman of the Appropriations Committee has all of the symbolic focus necessary from the overall budget resolution targets and the 302 allocations to make that a possibility that can be pursued in the appropriations process.

That's what we're dedicated to, the Administration in its entirety. The President's budget is specifically directed in that way, and the Senate support of that has been most beneficial.

The elements of the strategy, and in support of Senator Hutchison's comments of what our focus and objectives are all about. I think she summarized quite impressively is the early parts of this require a return of the shuttle to flight, a construction of the international space station, and then movement toward the broader objectives of what is contained in the President's statement, which is exploration. It is the act of exploration that is the primary focus of what our strategy is all about.

And rather than work through a specific list of those initiatives, if you'd permit me, Mr. Chairman, there's a short 5-minute piece that I can present here that highlights each of the elements of what is contained in the President's vision, and I'll conclude my comments with what this entails, if you would sir.

[A video was shown.]

Mr. O'KEEFE. Mr. Chairman, that is a brief summary of where we're heading that is derived from the President's directive in terms of what we see as the specific strategy and objectives we are to follow, and it has already begun. The implementation of that has already started with, as you referred to it, the remarkable successes we're seeing daily of the Mars expedition, Rover, Spirit, and

Opportunity, that are operating on that planet 125 million miles away, testimonial to its interest and support from across, I think, the broader expanse.

In the course of the last 75 days, our website has encountered 9 billion hits to the website. That's three times as many as all of last year and all of last year was five times as many as we'd ever gotten before. So the interest level, the enthusiasm, and certainly curiosity of what this particular mission certainly is evoking is clearly an expression of enthusiasm and support for where we're going and thirst for understanding.

Beyond that, once encountered upon the website there is an array of different visits that are done across everything we're engaged in at NASA to include this particular strategy, of which the support is building. So with that, Mr. Chairman, I appreciate the opportunity to testify and look forward to your questions as well.

[The prepared statement of Mr. O'Keefe follows:]

PREPARED STATEMENT OF HON. SEAN O'KEEFE, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Members of the Committee, thank you for this opportunity to appear today to discuss NASA's FY 2005 budget request. On January 14th, the President visited NASA Headquarters and announced his Vision for U.S. Space Exploration. In his address, the President presented a vision for our Nation that is bold and forward-thinking, yet practical and responsible—one that explores answers to longstanding questions of importance to science and society and develops revolutionary technologies and capabilities for the future, while maintaining conscientious stewardship of taxpayer dollars.

The vision forms the basis of the new U.S. space exploration policy, "A Renewed Spirit of Discovery," a copy of which is appended to this testimony as *Enclosure 1.* This policy is the product of months of extensive and careful deliberation. The importance of these deliberations increased with the findings of the *Columbia* Accident Investigation Board, which emphasized the importance of setting clear, long-term goals for the Nation's human space flight program. Inputs from Members of Congress informed the Administration's deliberations. Many others contributed ideas for the future of the space program. These deliberations were also the basis for formulating the President's FY 2005 budget request for NASA. A commission appointed by the President will advise NASA on specific issues for implementation of the policy's goals within four months.

Today, I will summarize the President's FY 2005 budget request for NASA, discuss the goals set forth in the new U.S. space exploration policy, outline the major implementation elements and their associated budget details, explain the implications of this directive for NASA's organization, and describe what the Nation's future in exploration and discovery will look like in the coming years.

FY 2005 Budget Summary

The President's FY 2005 Budget request for NASA is $16.244 billion, a 5.6 percent increase over FY 2004, as reflected in *Enclosure 2.* The NASA budget request is designed with four key principles in mind:

Compelling—The budget fully supports the Vision for U.S. Space Exploration, and provides for ongoing NASA mission priorities such as Aeronautics and Earth Science.

Affordable—The budget is fiscally responsible and consistent with the Administration's goal of cutting the Federal deficit in half within the next 5 years. NASA's FY 2005 budget will increase by $1 billion over 5 years, when compared with the President's FY 2004 plan; that is an increase of approximately 5 percent per year over each of the next 3 years and approximately 1 percent for each of the following 2 years.

Achievable—The budget strategy supporting the vision for sustainable exploration will *not* require large balloon payments by future Congresses and Administrations. Unlike previous major civil space initiatives, this approach is intentionally flexible, with investments in sustainable exploration approaches to maintain affordability.

After FY 2009, the budget projects that the exploration vision can be implemented within a NASA budget that keeps pace with inflation.

Focused—The budget begins the alignment of NASA's program structure with the exploration vision. We now have the needed compass with which to evaluate our programs and make the required tough decisions.

Vision Goals

The fundamental goal of this new policy is to advance U.S. scientific, security, and economic interests through a robust space exploration program. In support of this goal, NASA will:

- Implement a sustained and affordable human and robotic program to explore the Solar System and beyond;
- Extend human presence across the Solar System, starting with a human return to the Moon by the year 2020, in preparation for the human exploration of Mars and other destinations;
- Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about destinations for future human exploration; and
- Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.

Implementation Elements and Budget Highlights

To achieve these goals, NASA will plan and implement an integrated, long-term robotic and human exploration program, structured with measurable milestones and executed on the basis of available resources, accumulated experience, and technology readiness. Our initial plan is summarized in *Enclosure 3.*

NASA has developed a budget projection through 2020 to define the resources that will be available to achieve the vision for space exploration, as shown in *Enclosure 4* [sand chart]. The first five years are based on the details contained in the President's FY 2005 Budget request, and Fiscal Years 2010–2020 are based on roughly inflationary growth. NASA has taken the unusual step of projecting the budget beyond five years to demonstrate the exploration vision's sustained and affordable approach, which redirects resources within NASA and does not require balloon payments beyond the normal five-year budget horizon.

The President's five-year FY 2005–09 Budget request establishes necessary groundwork for the execution of the exploration vision. Proposed near-term investments are focused on technology risk reduction and flight experiments as well as robotic missions throughout solar system.

Enclosure 4 shows a rough estimate for the cost of the exploration initiative through the initial human lunar landing. This represents a bounding estimate based on experience and actual costs from relevant elements of the Apollo program. The estimate does not reflect architecture studies, design analysis, new technologies, and innovative approaches yet to be undertaken. It also does not reflect that the vision, unlike Apollo, views the lunar landing not as an end in itself, but as one step in a sustained human and robotic program to explore the solar system and beyond.

The policy envisions the following major implementation elements:

Space Shuttle—NASA will safely return the Space Shuttle to flight as soon as practical, based on the recommendations of the *Columbia* Accident Investigation Board. The budget includes $4.3 billion for the Space Shuttle, a 9 percent increase above FY 2004. Included in this total is an estimated $238 million for Return to Flight (RTF) activities in FY 2005. The RTF activities are under evaluation to confirm the estimated cost and associated out year phasing. The focus of the Space Shuttle will be finishing assembly of the International Space Station (ISS). With its job done, the Space Shuttle will be phased out when assembly of the ISS is complete, planned for the end of the decade. NASA will determine over the next year how best to address the issues associated with the safe retirement of the Space Shuttle fleet.

International Space Station—NASA plans to complete assembly of the International Space Station by the end of the decade, including those U.S. components that will ensure our capability to conduct research in support of the new U.S. space exploration goals, as well as those elements planned and provided by foreign partners. The budget provides $1.9 billion for ISS assembly and operations, a 24 percent increase above FY 2004. This increase forward funds $100 million in reserves to partially restore planned near-term reserve levels following the $200 million Congressional cut to Space Station in FY 2004 and provides $140 million in new funding for transportation services to the Space Station. We will separate, to the maximum extent practical, crew and cargo transportation for both ISS and exploration

missions. NASA will acquire ISS crew transport as required and will acquire cargo transportation as soon as practical and affordable. NASA envisions that commercial and/or foreign capabilities will provide these services.

The Administration is also prepared to address issues associated with obtaining foreign transportation services to the Space Station, including provisions of the Iran Nonproliferation Act, but, until the ISS Partnership adopts a specific implementation strategy, it is premature to identify specific issues.

U.S. research activities aboard the ISS will be focused to support the new exploration goals, with an emphasis on understanding how the space environment affects astronaut health and capabilities, and on developing appropriate countermeasures to mitigate health concerns. ISS will also be vital to developing and demonstrating improved life support systems and medical care. Consistent with this focus, the budget provides $343 million, a 61 percent increase above the FY 2004 request, for bioastronautics research to understand and mitigate risks to humans on exploration missions. Over the next year, the Biological and Physical Research Enterprise will conduct a thorough review of all research activities to ensure that they are fully aligned with and supportive of the new exploration vision.

New Space Transportation Capabilities—The budget provides $428 million to begin a new Crew Exploration Vehicle, named Project Constellation, which will provide crew transport for exploration missions beyond low-Earth orbit. The current budget planning is based on formulation concept studies to be conducted in FY 2004, preliminary design activities conducted in FY 2005–2006, a System Design Review in FY 2005, and a Preliminary Design Review in FY 2006. NASA plans to develop Project Constellation in a step-by-step approach, with an initial unpiloted test flight as early as 2008, followed by tests of progressively more capable designs that provide an operational human-rated capability no later than 2014. Project Constellation may also provide transportation to the Space Station, but its design will be driven by exploration requirements.

NASA does not plan to pursue new Earth-to-orbit transportation capabilities, except where necessary to support unique exploration needs, such as those that could be met by a heavy lift vehicle. The budget discontinues the Space Launch Initiative, although knowledge gained on the Orbital Space Plane will be transferred to Project Constellation.

Lunar Exploration—NASA will undertake lunar exploration and demonstration activities to enable the sustained human and robotic exploration of Mars and other destinations in the Solar System. Beginning no later than 2008, NASA plans to launch the first in a series of robotic missions to the Moon to prepare for and support human exploration activities. The budget provides $70 million for these robotic lunar test beds, increasing to $420 million by FY 2009. The policy envisions the first human expedition to the lunar surface as early as 2015, but no later than 2020. These robotic and human missions will further science and demonstrate new approaches, technologies, and systems—including the use of space resources—to support sustained human exploration to Mars and other destinations.

Exploration of Mars—The stunning images we have received since January 2004 from Mars, and the recent findings by the Opportunity Rover of evidence of large volumes of standing water on the Meridiani Planum, lay the foundation of the Vision for U.S. Space Exploration. NASA will enhance the ongoing search for water and evidence of life on Mars by pursuing technologies in this decade to be incorporated into advanced science missions to Mars in the next decade. Also starting in the next decade, NASA will launch a dedicated series of robotic missions to Mars that will demonstrate greatly enhanced capabilities and enable the future human exploration of the Red Planet. The budget provides $691 million for Mars Exploration, a 16 percent increase over FY 2004, and will double Mars Exploration funding by FY 2009. NASA will conduct human expeditions to Mars and other destinations beyond Earth orbit on the basis of available resources, accumulated experience, and technology readiness.

Other Solar System Exploration—Over the next two decades, NASA will conduct an increasingly capable campaign of robotic exploration across the Solar System. The budget provides $1.2 billion for Solar System Exploration missions to Jupiter's icy moons, to Saturn and its moon Titan, to asteroids and comets, and to other Solar System bodies. These missions will search for potentially habitable environments, evidence of life, and resources, and help us to understand the history of the Solar System.

Extrasolar Planets—NASA will launch advanced space telescopes that will search for Earth-like planets and habitable environments around other stars. The budget includes $1.1 billion for the Astronomical Search for Origins, a 19 percent increase over FY 2004, to support the recently launched Spitzer Space Telescope, James Webb Space Telescope development, as well as several future observatories. This

funding also supports investments to extend the lifetime of the Hubble Space Telescope to the maximum extent possible without a Shuttle servicing mission and to safely deorbit the observatory when its science operations cease.

Enabling Capabilities—NASA will pursue a number of key capabilities to enable sustainable human and robotic exploration across the Solar System. Among the most important of these capabilities is advanced power and propulsion, and the budget provides $438 million for Project Prometheus to develop these technologies for future robotic and human exploration missions. The budget also includes $636 million in other Human and Robotic Technology funding to pursue sustainable approaches to Solar System exploration, such as reusable and modular systems, prepositioned propellants, space resource utilization, automated systems and robotic networks, and in-space assembly. These technologies and techniques will be demonstrated on the ground, in orbit, and on the Moon beginning in this decade and extending into the next to help inform future exploration decisions. The budget projects that funding for these Human and Robotic Technology investments will grow to $1 billion by FY 2009.

The budget also includes innovative opportunities for U.S. industry, academia, and members of the public to help meet the technical challenges inherent in the new space exploration vision. The budget includes $20 million for the new Centennial Challenges program, which will establish competitions to stimulate innovation in space and aeronautical technologies that can advance the exploration vision and other NASA missions. The budget also provides $10 million for NASA to purchase launch services for its payloads from emerging launch vehicle providers. And as previously mentioned, the budget includes $140 million for Space Station transportation services.

Ongoing Priorities—The budget supports the Vision for U.S. Space Exploration, while maintaining NASA commitments in other important roles and missions.

NASA continues its commitment to understanding our changing global climate. The budget makes NASA the largest contributor to the interagency Climate Change Science Program with $100 million for the Climate Change Research Initiative. The budget includes $560 million for Earth System Science research, a 7 percent increase above FY 2004, to support research on data from 80 sensors on 18 satellites currently in operation. Work also continues on Earth observation missions in development or formulation, including $141 million (a 36 percent increase from FY 2004) for the National Polar Orbiting Environmental Satellite System Preparatory Project, and $240 million (a 37 percent increase from FY 2004) for missions in formulation, such as the Orbiting Carbon Observatory, Aquarius, and Hydros, as well as the Landsat Data Continuity Mission.

NASA maintains planned Aeronautics Technology investments to improve our Nation's air system. The budget includes: $188 million, a 4 percent increase above FY 2004, for technology to reduce aircraft accidents and improve the security of our Nation's aviation system against terrorist threats; $72 million, an 11 percent increase above FY 2004, for technology to reduce aircraft noise and improve the quality of life for residents living near airports; $209 million for technology to reduce aircraft emissions and improve environmental quality; and $154 million for technologies to increase air system capacity and reduce delays at the Nation's airports.

NASA will continue to make fundamental advances in our knowledge of the Sun and the Universe. The budget provides $746 million for Sun-Earth Connection missions, including the Solar Dynamics Observatory and the Solar-Terrestrial Relations Observatory. The budget also provides $378 million for Structure and Evolution of the Universe missions, including the Chandra X-ray Observatory and three major missions currently under development.

NASA maintains its role in science, engineering and math education. The budget includes $10 million for the newly authorized Science and Technology Scholarship program, which will help attract the Nation's best college students to NASA science and engineering careers. The budget also provides $14 million for the NASA Explorer Schools program, which seeks to attract students to mathematics and science during the critical middle school years. The Explorer Schools program is entering its third phase and will be selecting 50 new schools for a total of 150 participating schools.

NASA's education programs are, and will continue to be imbedded and directly linked to our vision for space exploration. Students now have unprecedented opportunities to engage in NASA flight programs, the observation of distant galaxies, and the robotic exploration of distant planets. Mission experiences link students and classrooms to NASA's diverse personnel, research facilities, telescopes, and planetary probes. Our successful efforts to "inspire the next generation of explorers" sustain a continuous pipeline of scientists, technologists, engineers, mathematicians, and teachers to carry forward our Nation's exploration goals.

Management of Human Capital, Facilities and Institution—NASA has the distinction of being the only Federal agency to earn top grades for the Human Capital and Budget and Performance Integration initiatives under the President's Management Agenda. Congress recently passed the NASA Flexibility Act of 2004. NASA is grateful for the hard work of this Committee in shaping this legislation to provide the necessary flexibilities to better attract and manage a diverse workforce. These flexibilities will be critical to implementing the exploration vision. The budget includes $25 million in FY 2005 to begin to address critical workforce skill and aging issues. NASA ratings have also improved in the Competitive Sourcing and E-Government initiatives, resulting in more total improvements than in any other agency. Although we received a disclaimed opinion on our recent audit statement, we are determined to pursue the right path in Financial Management bringing on a new financial system that will standardize accounting across the Agency and provide the tools necessary for improved program management. NASA remains committed to management excellence and believes it is essential to implementing the new exploration vision.

The budget includes funding for critical institutional capabilities, including $77 million for the NASA Engineering and Safety Center and $27 million for our software Independent Verification and Validation facility. The budget also provides $307 million, a $41 million increase versus FY 2004, for facilities maintenance.

Organizing for Exploration

To successfully execute the exploration vision, NASA will re-focus its organization, create new offices, align ongoing programs, experiment with new ways of doing business, and tap the great innovative and creative talents of our Nation.

The President has issued an Executive Order establishing a commission of private and public sector experts to advise us on these issues. Pete Aldridge former Undersecretary of Defense and Secretary of the Air Force, is Chair of the Commission. The President has named eight other commissioners to join Mr. Aldridge. The commission will issue its report within 120 days of its first meeting, which was held on February 11, 2004.

Immediately following the President's speech, we established an Exploration Systems Enterprise, which will have the responsibility for developing the Crew Exploration Vehicle and other exploration systems and technologies. Retired U.S. Navy Rear Admiral Craig Steidle, former manager of the Defense Department's Joint Strike Fighter Program, is heading this new organization. Relevant programs of the Aerospace Technology, Space Science, and Space Flight enterprises are being transferred to the Exploration Systems Enterprise. The Aerospace Technology Enterprise has been renamed the Aeronautics Enterprise to reflect its new focus.

As human explorers prepare to join their robotic counterparts, coordination and integration among NASA's diverse efforts will increase. The Exploration Systems Enterprise will work closely with the Space Science Enterprise to use the Moon to demonstrate new approaches, technologies, and systems to support sustained human exploration. NASA's Space Science Enterprise will have the responsibility for implementing early robotic testbeds on the Moon and Mars, and will also demonstrate other key exploration technologies—such as advanced power and communications—in missions to Mars and Jupiter's moons. NASA's Space Science Enterprise will eventually integrate human capabilities into exploration planning for Mars and other destinations.

Many other elements of the NASA organization will be focused to support this new direction. NASA's Biological and Physical Research Enterprise will put much greater emphasis on bioastronautics research to enable the human exploration of other worlds. NASA's Office of the Space Architect will be responsible for integrating the exploration activities of NASA's different Enterprises and for maintaining exploration roadmaps and coordinating high-level requirements.

As we move outward into the Solar System, NASA will look for innovative ideas from the private sector and academia to support activities in Earth orbit and future exploration activities beyond. Many of the technical challenges that NASA will face in the coming years will require innovative solutions. In addition to tapping creative thinking within the NASA organization, we will leverage the ideas and expertise resident in the Nation's universities and industry.

In his speech, the President directed NASA to invite other nations to share in the challenges and opportunities of this new era of exploration and discovery, and he directed us to fulfill our standing international commitments on ISS. We are discussing the impact of our vision implementation plans on the ISS with our partners, and as I have already indicated, we will complete the assembly of the ISS. The President called our future course of exploration "a journey, not a race," and other nations have reacted positively to the Vision; several have already contacted us

about joining in this journey. Building on NASA's long history and extensive and close ties with the space and research agencies of other nations, we will actively seek international partners in executing future exploration activities "that support U.S. goals" or "wherever appropriate".

NASA will also invigorate its workforce, focus its facilities, and revitalize its field centers. As exploration activities get underway, NASA anticipates planning, reviews, and changes to align and improve its infrastructure. In order to achieve the exploration vision, we will be making decisions on how to best implement new programs. While some of these necessary actions will be difficult, they are essential to achieving the goals of the overall effort before us. I urge you to consider the full context of what we will be proposing rather than any isolated, specific action. Such a perspective will allow us to move forward in implementing the vision.

FY 2003 Accomplishments

Much of the NASA's future ability to achieve the new space exploration vision is predicated on NASA's many previous accomplishments. The most visible NASA successes over the past year are the Spirit and Opportunity rovers currently on Mars. Already, the landscapes imaged by these twin rovers and their initial science returns are hinting at fundamental advances in our understanding of early environmental conditions on Mars; the announcement regarding the discovery of evidence that there was once liquid water on Mars' surface is a dramatic example of such an advance.

However, Spirit and Opportunity are not the only recent NASA mission successes. NASA and its partners successfully launched seven new Space Science missions (including the two Mars rovers), three new Earth Science missions, one new NASA communications relay satellite, and completed two Space Station deployment missions. Operating missions have achieved a number of notable successes, including the Stardust mission's successful flight through the tail of Comet Wild-2, initial images from the recently launched Spitzer Space Telescope, a ten-to 100-fold improvement in Earth's gravity map from the GRACE satellite, the most accurate maps of Earth temperatures to date from the Aqua satellite, and new insights into space weather and solar activity from Sun-Earth Connection missions.

NASA exceeded or met 83 percent of its annual performance goals for FY 2003. Among these accomplishments were demonstrations of new systems to improve air traffic control and to combat aircraft icing, improvements in battery, telescope sensor, and life support technologies; fundamental advances in understanding states of matter (from Space Station research); and the implementation of new remote sensing tools for tracking diseases and wild fires.

The Nation's Future in Exploration and Discovery

As the President stated in his speech, we are embarking on a journey, not a race. We begin this journey of exploration and discovery knowing that many years of hard work and sustained effort will be required, yet we can look forward to achieving concrete results in the near term. The vision makes the needed decisions to secure long-term U.S. space leadership. It provides an exciting set of major milestones with human and robotic missions. It pursues compelling science and cutting-edge technologies. It invites new ideas and innovations for accomplishing these bold, new endeavors. And it will provide the opportunity for new generations of Americans to explore, innovate, discover, and enrich our Nation in ways unimaginable today. This challenging Vision provides unique opportunities for engaging students across the country, "as only NASA can," to enter careers in science, engineering, technology, and math.

I sincerely appreciate the forum that the Subcommittee has provided today, and I look forward to responding to your questions.

ENCLOSURE 1

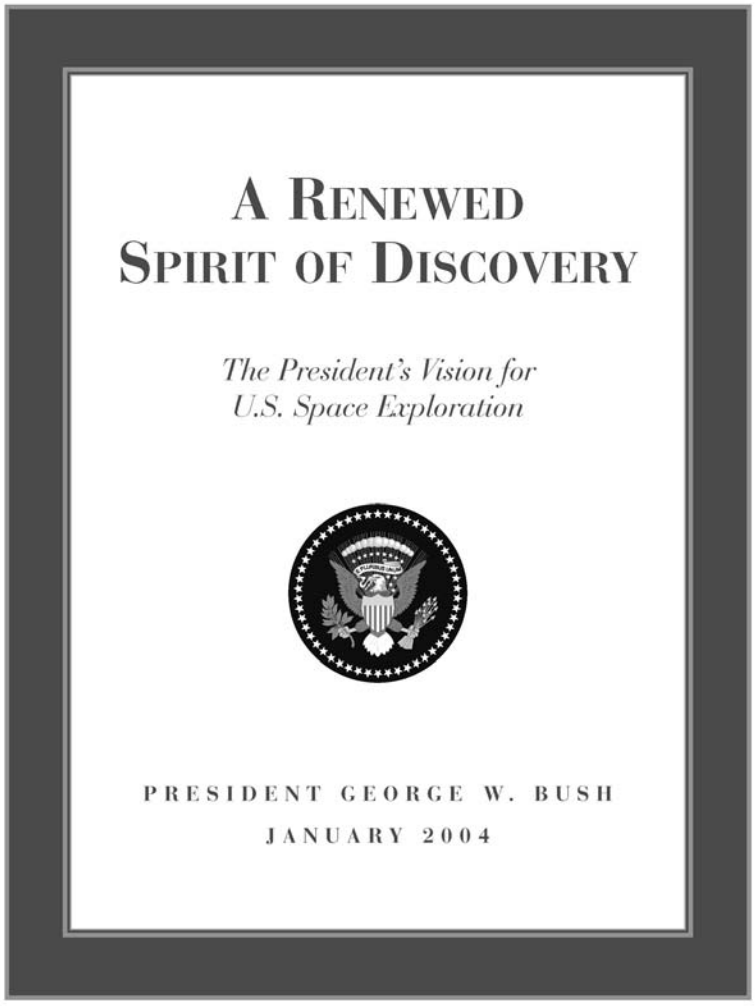

A RENEWED
SPIRIT OF DISCOVERY
The President's Vision for
U.S. Space Exploration
PRESIDENT GEORGE W. BUSH
JANUARY 2004

Table of Contents

Background

From the Apollo landings on the Moon, to robotic surveys of the Sun and the planets, to the compelling images captured by advanced space telescopes, U.S. achievements in space have revolutionized humanity's view of the universe and have inspired Americans and people around the world. These achievements also have led to the development of technologies that have widespread applications to address problems on Earth. As the world enters the second century of powered flight, it is time to articulate a new vision that will define and guide U.S. space exploration activities for the next several decades.

Today, humanity has the potential to seek answers to the most fundamental questions posed about the existence of life beyond Earth. Telescopes have found planets around other stars. Robotic probes have identified potential resources on the Moon, and evidence of water -- a key ingredient for life -- has been found on Mars and the moons of Jupiter.

Direct human experience in space has fundamentally altered our perspective of humanity and our place in the universe. Humans have the ability to respond to the unexpected developments inherent in space travel and possess unique skills that enhance discoveries. Just as Mercury, Gemini, and Apollo challenged a generation of Americans, a renewed U.S. space exploration program with a significant human component can inspire us -- and our youth -- to greater achievements on Earth and in space.

The loss of Space Shuttles *Challenger* and *Columbia* and their crews are a stark reminder of the inherent risks of space flight and the severity of the challenges posed by space exploration. In preparation for future human exploration, we must advance our ability to live and work safely in space and, at the same time, develop the technologies to extend humanity's reach to the Moon, Mars, and beyond. The new technologies required for further space exploration also will improve the Nation's other space activities and may provide applications that could be used to address problems on Earth.

Like the explorers of the past and the pioneers of flight in the last century, we cannot today identify all that we will gain from space exploration; we are confident, nonetheless, that the eventual return will be great. Like their efforts, the success of future U.S. space exploration will unfold over generations.

Goal and Objectives

The fundamental goal of this vision is to advance U.S. scientific, security, and economic interests through a robust space exploration program. In support of this goal, the United States will:

- Implement a sustained and affordable human and robotic program to explore the solar system and beyond;
- Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;
- Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and
- Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.

Bringing the Vision to Reality

The Administrator of the National Aeronautics and Space Administration will be responsible for the plans, programs, and activities required to implement this vision, in coordination with other agencies, as deemed appropriate. The Administrator will plan and implement an integrated, long-term robotic and human exploration program structured with measurable milestones and executed on the basis of available resources, accumulated experience, and technology readiness.

To implement this vision, the Administrator will conduct the following activities and take other actions as required:

A. Exploration Activities in Low Earth Orbit

Space Shuttle

- Return the Space Shuttle to flight as soon as practical, based on the recommendations of the Columbia Accident Investigation Board;
- Focus use of the Space Shuttle to complete assembly of the International Space Station; and
- Retire the Space Shuttle as soon as assembly of the International Space Station is completed, planned for the end of this decade;

International Space Station

- Complete assembly of the International Space Station, including the U.S. components that support U.S. space exploration goals and those provided by foreign partners, planned for the end of this decade;

- Focus U.S. research and use of the International Space Station on supporting space exploration goals, with emphasis on understanding how the space environment affects astronaut health and capabilities and developing countermeasures; and

- Conduct International Space Station activities in a manner consistent with U.S. obligations contained in the agreements between the United States and other partners in the International Space Station.

B. Space Exploration Beyond Low Earth Orbit

The Moon

- Undertake lunar exploration activities to enable sustained human and robotic exploration of Mars and more distant destinations in the solar system;

- Starting no later than 2008, initiate a series of robotic missions to the Moon to prepare for and support future human exploration activities;

- Conduct the first extended human expedition to the lunar surface as early as 2015, but no later than the year 2020; and

- Use lunar exploration activities to further science, and to develop and test new approaches, technologies, and systems, including use of lunar and other space resources, to support sustained human space exploration to Mars and other destinations.

Mars and Other Destinations

- Conduct robotic exploration of Mars to search for evidence of life, to understand the history of the solar system, and to prepare for future human exploration;

- Conduct robotic exploration across the solar system for scientific purposes and to support human exploration. In particular, explore Jupiter's moons, asteroids and other bodies to search for evidence of life, to understand the history of the solar system, and to search for resources;

- Conduct advanced telescope searches for Earth-like planets and habitable environments around other stars;

- Develop and demonstrate power generation, propulsion, life support, and other key capabilities required to support more distant, more capable, and/or longer duration human and robotic exploration of Mars and other destinations; and

- Conduct human expeditions to Mars after acquiring adequate knowledge about the planet using robotic missions and after successfully demonstrating sustained human exploration missions to the Moon.

C. Space Transportation Capabilities Supporting Exploration

- Develop a new crew exploration vehicle to provide crew transportation for missions beyond low Earth orbit;

  - Conduct the initial test flight before the end of this decade in order to provide an operational capability to support human exploration missions no later than 2014;

- Separate to the maximum practical extent crew from cargo transportation to the International Space Station and for launching exploration missions beyond low Earth orbit;

  - Acquire cargo transportation as soon as practical and affordable to support missions to and from the International Space Station; and

  - Acquire crew transportation to and from the International Space Station, as required, after the Space Shuttle is retired from service.

D. International and Commercial Participation

- Pursue opportunities for international participation to support U.S. space exploration goals; and

- Pursue commercial opportunities for providing transportation and other services supporting the International Space Station and exploration missions beyond low Earth orbit.

ENCLOSURE 2

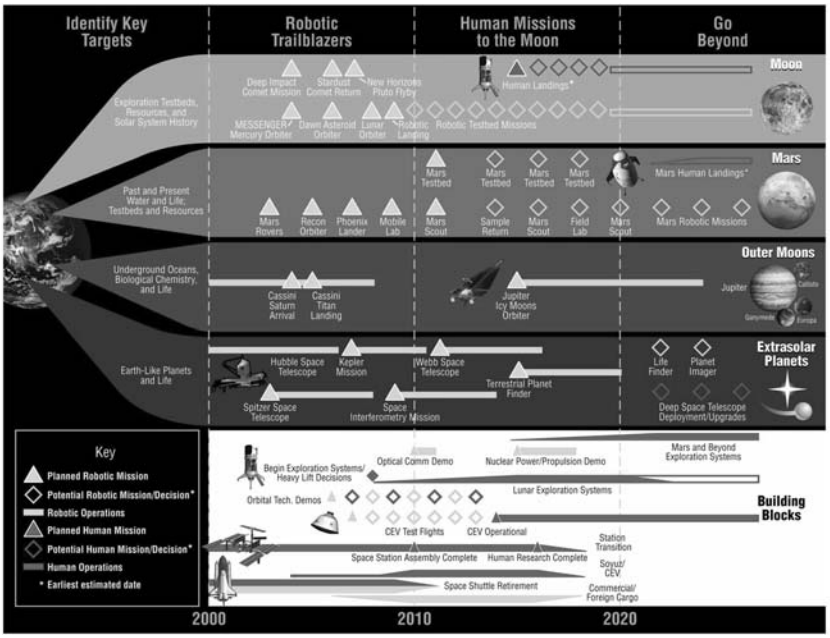
National Aeronautics and Space Administration
President's FY 2005 Budget Request

(Budget authority, $ in millions)	FULL COST						Chapter Number
By Appropriation Account	Est. Conf. Rept.						
By Enterprise	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	
By Theme							
Exploration, Science & Aeronautics	**7,830**	**7,760**	**7,869**	**8,320**	**8,900**	**9,091**	ESA-SUM 1
Space Science	**3,971**	**4,138**	**4,404**	**4,906**	**5,520**	**5,561**	ESA 1
Solar System Exploration	1,316	1,187	1,202	1,300	1,392	1,438	ESA 2
Mars Exploration	595	691	724	944	1,188	1,268	ESA 3
Lunar Exploration		70	135	280	375	420	ESA 4
Astronomical Search for Origins	899	1,067	1,196	1,212	1,182	927	ESA 5
Structure & Evolution of the Universe	406	378	365	382	425	457	ESA 6
Sun-Earth Connections	755	746	781	788	958	1,051	ESA 7
Earth Science	**1,613**	**1,485**	**1,390**	**1,368**	**1,343**	**1,474**	ESA 8
Earth System Science	1,522	1,409	1,313	1,290	1,266	1,397	ESA 9
Earth Science Applications	91	77	77	77	77	77	ESA 10
Biological & Physical Research	**985**	**1,049**	**950**	**938**	**941**	**944**	ESA 11
Biological Sciences Research	368	492	499	496	500	502	ESA 12
Physical Sciences Research	357	300	220	210	210	210	ESA 13
Research Partnerships & Flight Support	260	257	232	232	231	232	ESA 14
Aeronautics*	**1,034**	**919**	**957**	**938**	**926**	**942**	ESA 15
Aeronautics Technology	1,034	919	957	938	926	942	ESA 16
Education Programs	**226**	**169**	**169**	**171**	**170**	**170**	ESA 17
Education Programs	226	169	169	171	170	170	ESA 18
Exploration Capabilities	**7,521**	**8,456**	**9,104**	**9,465**	**9,070**	**8,911**	EC-SUM 1
Exploration Systems*	**1,646**	**1,782**	**2,579**	**2,941**	**2,809**	**3,313**	EC 1
Human & Robotic Technology	679	1,094	1,318	1,317	1,386	1,450	EC 2
Transportation Systems	967	689	1,261	1,624	1,423	1,863	EC 3
Space Flight	**5,875**	**6,674**	**6,525**	**6,524**	**6,261**	**5,598**	EC 4
International Space Station	1,498	1,863	1,764	1,780	1,779	2,115	EC 5
Space Shuttle	3,945	4,319	4,326	4,314	4,027	3,030	EC 6
Space Flight Support	432	492	435	430	456	453	EC 7
Inspector General	**27**	**28**	**29**	**30**	**31**	**32**	IG 1
TOTAL	**15,378**	**16,244**	**17,002**	**17,815**	**18,001**	**18,034**	
Year to year increase		5.6%	4.7%	4.8%	1.0%	0.2%	

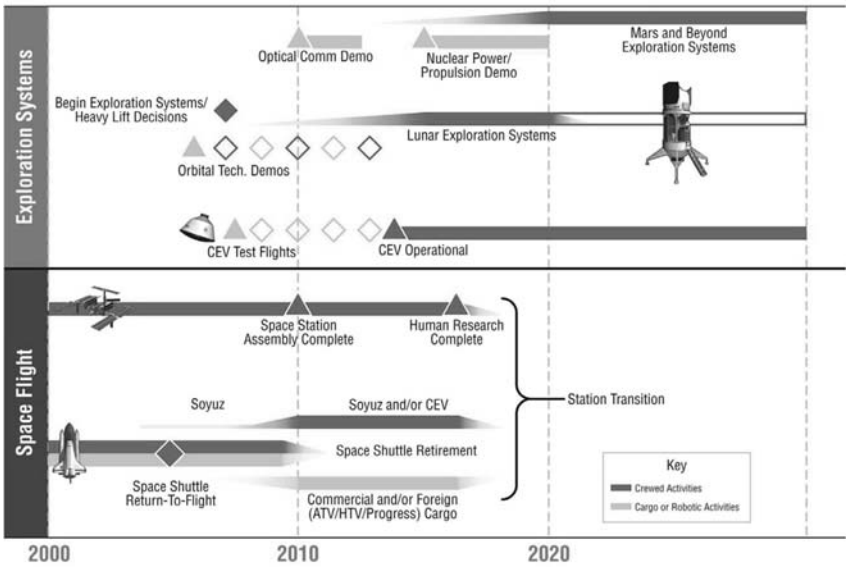
*In FY 2004 Aeronautics and Exploration Systems will become separate Enterprises

NOTE: May not add due to rounding

ENCLOSURE 3



Exploration Building Blocks



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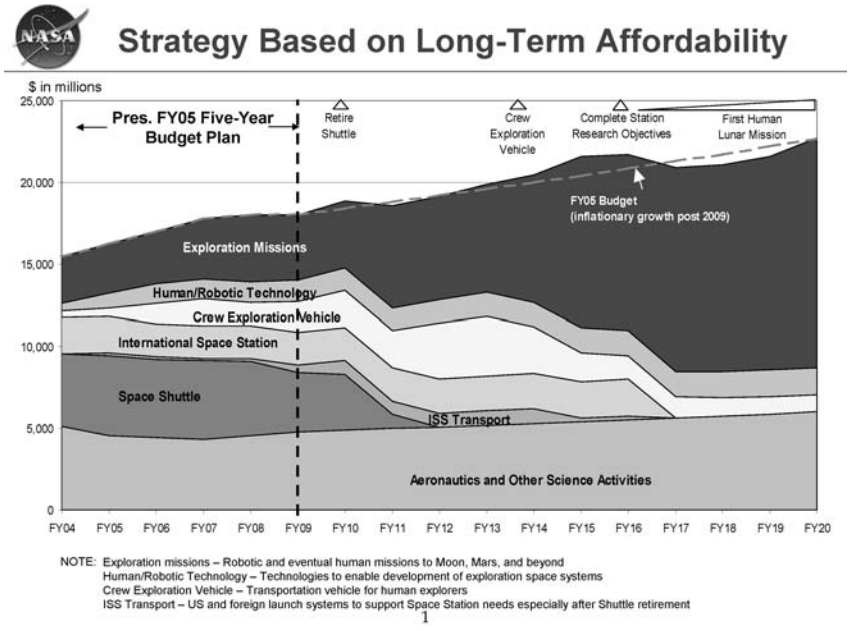

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Senator BROWNBACK. Thank you very much, Mr. O'Keefe. Let's run the clock at 5 minutes here and we'll let people go through quickly on items. Mr. O'Keefe, I want to pose a question that I think may take some time to think through and so I'm not expecting a hip shot today on this from you.

One, a number of people supporting Hubble servicing, I know that was an issue of some concern earlier on. I wonder if there is a way that we can do this without the shuttle. I know NASA's being looking at, OK, we need to do it with the shuttle or if we've got to have other missions with the shuttle, or is there a way to do it without the shuttle. And I'd like a thought on this.

The bigger point I would make to you is that the mission of what the President has outlined, it's great, I support it fully. It takes too long. We've got China, India going back to the moon. China's moving theirs up to 2006 with the initial wave going forward, India 2007. Maybe those dates slip on their part and they don't hit it, but if we're talking about 2014 and no later than 2020 back to the moon, it looks like to me we're going to be about fourth or fifth in line while somebody else is there.

Now, then that comes back to an issue of money and that's what the hearing's about is the budget. You've got about $4 billion to $5 billion annually going into the Space Shuttle program. You've heard a range of thoughts up here about space shuttle. If we could get more of those funds moved into exploration and missions earlier and do the international space station off of contracting with either private sector or with other countries, with what we're doing with Russia on a quicker basis, could we transition the money from

shuttle to exploration and missions and step up the dates by which we could get back to the moon, Mars, and beyond so that we're not conceding that frontier to others?

You've created a great electricity on the Mars mission, the website hits that you've talked about, front page of the paper. It's kind of like the day of exploration is back and we've been stuck in the mud here for some period of time and now we can do this.

To follow that on with, it's going to be 2020 before we're back on the moon with a human and on, 16 years, that seems like quite a long frame of time and I got to think most of it's tied budgetarily. So I wonder if you could look at or think about, and maybe this is one that takes some time doing that, on the shuttle. I mentioned previously about a NASA BRAC process so that we could take some of the resources like we're doing in the military and try to consolidate them in more areas so that you—can we take some of the funding going to various areas within NASA and let's concentrate that into exploration. I've mentioned at hearings before of getting sponsorships from the private sector so that we can get more private dollars dedicated to space exploration missions.

I ask you to think about those. Those you're willing to respond to today I'd be delighted to hear from you or if you want to kick them around some internally, I'd be happy to visit with you about those later. All this is in an effort to try to get more money into explorations and missions faster without busting through an overall budget cap that we have in a tight budget.

So I would put those forward to you and appreciate any response you would care to give today or we can continue to conversation later.

Mr. O'KEEFE. Yes, sir. Thank you, Mr. Chairman. I'll take you up on the opportunity on both counts. I'd definitely like to pursue it further in discussion because we really have lent a lot of consideration to the latter question you posed.

But to the first point, to the issue of the Hubble servicing mission, very quickly let me include in the record at this point if you'd permit a more extensive discussion of all the factors that go into the question of the servicing mission relative to compliance with the *Columbia* Accident Investigation Board recommendations.

We're about two objectives. The first one is to try to extend the service life of Hubble by whatever means possible. There are a lot of different ways to do that, and we're examining a series of robotic, autonomous methods that would extend the battery power on the Hubble for a longer period of time, and we'll see what—various proposals that have been made and we'll see what it's going to take to work that out.

In addition to that, we also want to be sure we comply with every single recommendation of the Accident Investigation Board's findings and move forward to return the shuttle to flight at the lowest risk that we can possibly attain. I think that's the dual objective and I'll submit that for the record if you would, sir. But I think we'll be seeing some real movement on that front in a very, very short period of time in terms of looking at other alternatives, along with the National Academy of Sciences' examination, the GAO's review that's been commissioned by the Appropriations

Committee to consider that as well. All that will be converging here I think in the next couple of months.

To the second part of your question, which is a really intriguing issue, and it's one that we frankly wrestled with endlessly within the administration during the course of the inter-agency process to come up with the options for the President's consideration. At the beginning and at the end and at any step in between, his consistent reminder to us all was, it is about the act of exploration, folks. That's what this focus really needs to be. It is the curiosity and the understanding on the part of human desire to want to know and understand ought to be the central guiding feature, and then there are a whole range of different options you can pursue in the process of getting there.

How quickly you achieve that is a limit, as you've correctly pointed out, of not only resource but also of the technology and how it can be employed in ways that develop that systems integration approach necessary to yield that result. And what we've developed, I think, is an approach that attempts to accomplish each of those imperatives in turn.

The first one is to complete the international space station, because we're going to need to understand what the effects are for long duration, long endurance space flight necessary and through expeditionary missions to understand precisely what the effect is on human physiology. We're just beginning to scratch the surface on that now that we're in our third continuous year of a permanent presence in space.

All of the components and modules are stacked up at the Kennedy Space Center, arriving there, being tested, integrated, worked out to make sure that they're ready for flight. All of them were designed to go into the shuttle payload, and so as a consequence that is the most efficient way to do that as expeditiously as we can, and the long pole in the tent is return to flight and getting the shuttle back up to the point where we can complete that effort and then accomplish the retirement of shuttle at the conclusion of the construction of the international space station.

And that's precisely what the chart attempts to demonstrate is it will take us through the end of the decade to complete that task in compliance with our international agreements and to harvest the research that I think you very accurately refer to as an imperative necessary in order to understand precisely what the long-term effects are in human physiology. This is the most efficient, most thorough way to do it. It takes the least amount of time to accomplish that task.

The other approach——

Senator BROWNBACK. Director, I'm going to have to interrupt you just a minute. I've got to leave for the White House. There's a signing ceremony on the Unborn Victims of Violence, so I'm going to slip out to that and we'll continue this dialogue with you. Senator Stevens will chair the hearing, and I'm apologetic for doing that, but I'm just on that timeframe, and I apologize.

Mr. O'KEEFE. Not at all, sir.

Senator BROWNBACK. Senator Nelson.

Senator NELSON. As we look to the future, I think what has been accomplished by these two little rovers is going to have some ex-

traordinary implications for the future. Now that there is the evidence that there was water on Mars, and as you go with your other probes in 2007, 2009, 2011, if I've got my years correctly, you can imagine if in the course of one of those probes that they're digging around and suddenly find a fossil or something of that nature that would indicate that there was life on Mars, what I think is the excitement, the igniting of the imagination, the igniting of the wanting to understand and explore, is going to happily swamp the budgetary process and have every reason to want to accelerate to go to Mars if you find that evidence.

And a month ago I wouldn't be saying this, but you have now found that there was water on Mars, so I think the way that you lay out the budget gives you the opportunity of flexibility by the time 2009 and 2011 is coming around, so that then, according to the development of technology, we can decide is it absolutely essential that we go back to the moon. It might be, but who knows? The development of technology at that point, it may not be.

Speaking of that, as we go with your budget here and we want access to the ISS, the space station, after you retire the shuttle, which is somewhere around 2010, 2011, and you're developing some kind of nuclear propulsion, how is that going to affect some of the non-proliferation acts that we find that we are dealing with here on the earth?

Mr. O'KEEFE. We don't believe there's a specific treatment relative to the proliferation acts and the statutory governance thereof. We are developing, designing and developing a reactor capacity under Project Prometheus. It'll be first demonstrated and tested on a mission at the turn of the next decade to Jupiter.

Thereafter, the ultimate goal would be to use as power generation and propulsion capability the capacities developed under that program, which should be done in full compliance with all existing law. We're working this in concert with the Department of Energy. The naval reactors community is now a partner in that design and development effort and they've had 50 years of great success of doing this in full compliance. We intend to continue that same approach, and this will be a power generation and propulsion capacity to accomplish that task.

Senator NELSON. Looking at trying to get back flying again with the shuttle, tell me about these recent discoveries of the rudder, the vertical stabilizer, the speed brake, and how those gears were not connected there in the proper way. How could that potentially delay the return to flight in next March of 2005?

Mr. O'KEEFE. The rudder speed brake actuator issue, along with the development of a boom camera, or a camera to be installed at the edge of a boom in order to do a full visual inspection on the edges of the leading edge of the orbiter, plus the development and ultimate testing of design techniques to repair the reinforced carbon-carbon leading edge of the orbiter, as well as the thermal protection system tiles, those are all the long poles in the tent that are the ones that primarily have driven the timing of what we may look at for return to flight.

The other major factor in this is our commitment and I think real firm desire to be sure that at least the first couple of flights, which will almost exclusively be test demonstration flights to make

sure we've got all the pieces of this done precisely right in accordance with the recommendations, has to be done during day-lit hours, so that we can conduct all the appropriate imaging at every single step through main engine cutoff.

There are only a finite number of periods of time in a calendar that permit that. So past October, there are only about two or three windows in which that's feasible and for just single digit days at a time. The first major opening is in early March of next year, in which we have a continuous period of full daylight launch from launch to main engine cutoff so that the imagery can be done completely.

So all those factors combined are what ultimately in our return to flight plan have driven us to the current projection of where we see an early March next year opportunity, and it's driven by every one of those. The rudder speed break issue was not something that was called out by the Accident Investigation Board. That's something we found as we went through the due diligence of the major modification effort for all three of the orbiters and determined that nope, it's too close, we couldn't prove that it was safe so let's take them all out and make sure we examine the corrosion and the cracking that occurred to understand precisely why it had happened.

The correction is not deemed to be an insurmountable problem, but understanding the reasons why it occurred is the bigger issue we're really wrestling with. And right now, everything appears to be well on track to making that time-frame work very, very successfully.

Senator STEVENS. [presiding]. Senator Wyden?

Senator WYDEN. Thank you, Mr. Chairman. Mr. Administrator, as you could tell from my opening comment, I continue to try to fit all of this into the vessel of sort of comparing what we've got now, what's going to be new and the cost benefit.

Let me start, if I could, we're talking about a lot of money for a new initiative and I think everybody, and you, to your credit, said there's a ways to go to get some of the old initiatives completed. In terms of the CAIB report, how much is it going to cost specifically to finish the work envisioned there? For example, it seems to me we're a long way away from having an answer to how to do the independent technical authority, and every time I try to figure out what's going on here, it's, well, don't sweat it, Ron, it's in the budget somewhere.

And I think we really need, again, as part of this comparing where we're headed to what we've already got obligated, we need to know, for example, how much more it's going to cost to finish up the accident investigation exercise and particularly the independent technical authority which we all see as critical?

Mr. O'KEEFE. Absolutely, and I apologize if we've been elusive in those responses. There is an update of the current return to flight plan that's due to be issued by, I think next Friday. We'll be sure that a copy arrives so that you can examine that in detail. We update it roughly every 30 days, or once a month, every 6 weeks. And as a result, the latest projection of cost, which escapes my memory right at the moment, is contained in that report, as it was in the

last report that we issued in early March. Again, I'm just dropping on remembering the exact number.

Senator WYDEN. Does it include, for example, the cost of completing that independent technical authority?

Mr. O'KEEFE. Yes, sir. All the projections we've included, everything we think we understand about what it's going to take to implement every one of these recommendations is captured in that report.

Senator WYDEN. Any of those nice people sitting behind you have that number? How much it's going to cost to finish the work envisioned in the CAIB report.

Mr. O'KEEFE. Total amount that's in Fiscal Year 2004 right now that came over in the operating plan is $265 million. In 2005, the budget number that's contained therein is 238, and we already incurred $94 million at the end of 2003. So in total we're looking at a projection that's going to be on the order of $600 million to $700 million roughly to implement all those findings and recommendations.

Senator WYDEN. That's including independent technical authority?

Mr. O'KEEFE. That's the current projection, but I've got to really improve that forecast, because how we actually go about implementing that is what is currently about to be concluded right now. There's a lot of discussion that's gone on with the Stafford-Covey return to flight task group, and the options were surrounding, narrowed down to about two or three, and precise cost estimates of how many people it's going to take and so forth, should not be an enormous number. I just can't imagine that because we're looking at existing capabilities.

Senator WYDEN. The plan calls for a new crew exploration vehicle that would be tested by 2008, and we're told that there really aren't any current plans for the vehicle. And I think my question would be, how does the agency build and test an entire new space vehicle in 4 years when there really isn't a vision, at least at this point, for even the basic aspects of it?

Mr. O'KEEFE. Yes, sir. No, quite the contrary. The crew exploration vehicle is building on everything we worked on the orbital space plane. Seventy-five percent of the characteristics of what you'd need for a capability to go from here to station and returning on a crew transfer vehicle is common with an exploration vehicle that would go beyond low earth orbit, so what we've basically done is evolved the orbital space plane to say let's add the important mission objective to go beyond station on a return to the moon based on a variety of systems components and how you array them in the first spiral development that was due to occur in 2008 and then thereafter.

So an awful lot of the work that would be required for Project Constellation has been accomplished over the past 18 months and we're building on that in order to design this capability now. The approach that we are going to look to and what we do—are looking at is what is the appropriate acquisition strategy, if you will, of how to develop and then acquire that capability by potentially looking at competing designs, varying approaches, because all that got worked out as part of the orbital space plane, and again, it's very,

very common with where we go with the CEV, Project Constellation capability.

So a lot of work's been done and we're way up on the step on this relative to where we would be had we started from scratch.

Senator WYDEN. Now the Hubble is by everybody's calculus a very big success story, arguably providing more scientific data than some of the missions. Why drop a relatively inexpensive and successful program at this point?

Mr. O'KEEFE. We certainly are not dropping it at all. As a matter of fact, we're looking extensively at every possible option to extend its service life. It was designed to operate through 2005. We can exceed that without doing anything and the current projection is that even if we did nothing at all, Hubble will probably operate at least through 2007, maybe even 2008.

With some judicious use of its operating time and how it's actually pointed and so forth, the battery power, the gyros, everything else, are strained a lot less if we're really careful and conservative about how we utilize it, could get more time than that out of it. In addition, we've also asked now for a variety of proposals that I referred to in the comments the Chairman made to look at a robotic autonomous means to extend the battery life, and that appears to be something that may have some real traction to it that could, again, keep the Hubble operating at its present condition for years longer.

And in addition to all that, what's in the budget is an acceleration of the James Webb telescope, which is, again is a much greater follow-on to the Hubble capabilities, the continued operation of the Spitzer telescope, which was deployed last November, as well as the continued operation of Chandra and the launch of the Keppler in 2007. So the combination of all those, we're trying to look at that. We're not giving away Hubble any time earlier than we have to.

Senator WYDEN. My time is up and if I can just make one last point, Mr. Chairman, because I know colleagues are here, I think it comes back to the concern I raised earlier, is you, Mr. Administrator, are extraordinarily capable, and I asked you questions that go right to the heart of some of the current programs and you basically gave me an answer, we're going to figure out how to do that. And I admire that, I mean, I think that's part of your history when I supported you from the time I chaired your hearing on your confirmation.

But I think we've got to have that report on the cost benefit analysis of manned flight versus the alternatives. When you can expect that we'll actually have a full scale analysis along the lines of what we've been talking about?

Mr. O'KEEFE. Exactly. I appreciate that, sir, and thank you for your patience. Our original effort was we looked at middle to late February. It got delayed about a month, and as I understand it, at least the preliminary, the first draft of this construct has been briefed to the committees last week, and we're anticipating a completion of the report and an actual write-up within the next 30 days.

But it really is revealing the kinds of things that you first initiated by your suggestion and recommendation that we look at this

tradeoff and cost benefit analysis, and my cut of it is that it really demonstrates that if you want to look at individual missions, by all means robotic capabilities are the way to go in terms of cost, but you have to have extreme frequency of them, as opposed to human missions.

And so the issue then you have to really weigh is the question of how many multiples can you afford in a robotic mission, or is it a single-point solution situation like a Hubble? Hubble is a perfect example of this where we may actually see the advantages of at least maintaining its current service performance characteristics by a robotic capability. If you want to enhance that capability, you've got a whole other set of challenges you've got to work through that do pose the risks.

But we will have that shortly and I understand the outlines of it have been briefed and I'd be delighted to sit down and talk with you about it as well.

Senator WYDEN. Thank you, and thank you, Senator Stevens.

Mr. O'KEEFE. Thank you, Senator. I appreciate your patience.

STATEMENT OF HON. TED STEVENS,
U.S. SENATOR FROM ALASKA

Senator STEVENS. This is probably a stupid question but I've asked them before.

Mr. O'KEEFE. Never, sir, never.

Senator STEVENS. Any chance that you could test some of these things that need testing on the unmanned launches that are going to take place between now and March, this break actuator, the external tank fixes? Is that possible to test them on something that's unmanned?

Mr. O'KEEFE. Probably not. What we're looking at is—let me be very specific—the repair techniques that we're looking at we are in fact conducting on the KC–135 aircraft that we have that simulates the micro gravity condition for seconds at a time, and there are various approaches we're using too with some land-based systems, which we're using arc jet testing and a variety of other things that we think will simulate it, but it's never going to be anything like actually trying to conduct this on orbit.

And so there are a number of very key repair techniques that are required, and the external tank question is one that's very significant in that regard.

Senator STEVENS. Now, I understand that the shuttle delivers about 25 tons and brings back about 20 tons. Do you know of any vehicle under development today that could replace those capabilities as soon as the shuttle could if it will work?

Mr. O'KEEFE. Not that I'm aware of, sir.

Senator STEVENS. It's further my understanding that if it does work, you've got about 30 missions that would start sometime early next year. Is that right?

Mr. O'KEEFE. Yes, sir. The approach max-end is about 30. What we're trying to do right now is employ a rigorous approach that every single item that needs to go to station must fight its way into the manifest, demonstrate why it needs to be there. So what we're looking at is the components and the modules that have been delivered at the Kennedy Space Center and are anticipated to be deliv-

ered over the course of this next year that require test and checkup to complete the international space station. That'll take at least for assembly flights at least 15 flights. When you add the logistics flights and requirements for additional activities, it could be as many as 25.

So as a consequence we're really trying to minimize the number of flights to complete the station and assure that we do it right and do it in a way that complies with all of the recommendations of the Accident Investigation Board.

Senator STEVENS. Where I'm getting is, let's assume the shuttle proves, all the test proves you can use the shuttle, and you start using the shuttle in 2005, you're going to use it up to about 2010 as I understand it. Will that use slow down the development of the other replacement aircraft?

Mr. O'KEEFE. No, sir, not at all. As a matter of fact, the approach we're using now is to phaseout the shuttle at the time in which we complete station, but continue to operate the international space station to yield the research requirements we have there and concurrently develop the Project Constellation crew exploration vehicle that will require at least——

Senator STEVENS. What's IOC for it if it's going to replace the shuttle, it's 2010?

Mr. O'KEEFE. No, sir. The earliest we would see on the first spiral that would be an unmanned capacity would be 2008, probably a second or third development thereafter, and the first human-rated capacity we're looking at, to be realistic and to be conservative about it, is probably 2013 to 2014.

Senator STEVENS. You're contemplating running the shuttle until you're certain you have a replacement, is that right?

Mr. O'KEEFE. Yes, sir.

Senator STEVENS. Thank you very much, Mr. Chairman.

STATEMENT OF HON. TRENT LOTT,
U.S. SENATOR FROM MISSISSIPPI

Senator LOTT. Mr. Chairman, I must say before you leave that I think that our witness here, the Administrator would need to know that you were just saying what an excellent job that Administrator O'Keefe does, and I said, well, he should, he was trained by you, and he said, I know. So he's proud of his——

Senator STEVENS. I thought of it but I didn't say it.

Mr. O'KEEFE. Thank you, Mr. Chairman. I'm deeply appreciative.

Senator NELSON. I wanted to get Senator Stevens before he left. Senator Stevens took the appropriations bills with him and they left. Is he gone? I think there was a disconnect there on what he understood the Administrator to answer, and I just want to make sure that's clear in the mind of the Chairman of the Appropriations Committee.

Senator LOTT. Well, why we're waiting on him to come back let me go ahead if I could. Is he coming?

Senator NELSON. Yes. Senator Stevens, I understood that there was a disconnect there in what you understood the Administrator to say. Your question was, was the Shuttle going to be flown until the new vehicle was ready. And the answer to that is not what I thought you understood, yes, but the Shuttle under this plan is to

be phased out by 2010. The new vehicle would not be ready for a human to fly until, the Administrator said, at the earliest 2013 and probably 2014, and therein is a three- or four-year hiatus in which there is no man-rated capability as an American rocket to get to the Space Station.

I just wanted to clarify that, given the fact that you occupy the esteemed position as Chairman of Appropriations.

Senator STEVENS. Only six more months, but we have looked at, we have discussed that with the administrator. I do think we'll have to reexamine retiring the shuttle. The question is, will the shuttle work? If we can fly people in tankers that are 45 years old, we can fly people in shuttles that are 35 years old.

Senator LOTT. [presiding]. Mr. Administrator, I asked you a question right along these lines when we met a few weeks ago. I'm concerned about that gap. Do you want to comment further on this exchange you just had on this particular concern? It is—it's a natural thing for us to be looking at and thinking about, maybe it's a simple answer like the one the Chairman just noted. How do you respond to that?

Mr. O'KEEFE. It turns on two assumptions. The first one is that the objective is to complete the international space station by the end of the decade. We'll see how long that takes and that's the way we're currently planning it is to achieve that goal. There's not a lot there that would suggest that that would be an insurmountable objective. Nevertheless——

Senator LOTT. A lot of it will depend on what funding you get from us, right?

Mr. O'KEEFE. Yes, sir, absolutely, no question about it, always does. There is no other alternative than that, that's for sure. But it also, it really depends, in addition to the resource base that the Congress would be willing to provide, it also depends on our capacity to actually mount those missions, and that's what we're really making sure we do right by the return to flight activity.

So if everything works screamingly successful, we could be looking at retirement at the end of the decade. Concurrently, if everything works at a very conservative pace, the earliest we could look at—or I should say the latest we'd look at is the crew exploration vehicle delivery in 2013, 2014. The convergence of both of those events could produce something that's more near simultaneous if we're able to accelerate the spiral development and do this in a way that's successful.

And the basic approach we're using this time around, because we've heard the critics time and time again, we keep building everything on the anticipation of wild success, and that's not what we're going to do this time. Crew exploration vehicle, we're going to demonstrate it in several spirals in its capabilities and components before we actually go to the human certified—human rated, excuse me—crew exploration vehicle. And it may occur earlier than that if this is good as we think it could be, but rather than set expectations realistically, we're trying to do this as reasonably as we can and we may yet see an earlier accomplishment if everything works exactly right.

Senator LOTT. Thank you. You may have already answered some of the questions I'm going to ask so I'll state them briefly and

maybe you can respond briefly. First of all, I do appreciate that fact that as administrator of NASA you do get out and go out around the country and meet with the people that make NASA work, you go to the different facilities that we have in Florida, Texas, Mississippi, and Alabama, all of them, and that makes people feel better about the whole program.

You were in Mississippi a couple of weeks ago and maybe some other facilities right around that same time. I understand you had a real good visit.

Mr. O'KEEFE. Outstanding. It's always wonderful to be there.

Senator LOTT. Did you get to go home over in New Orleans?

Mr. O'KEEFE. No, sir, I didn't. It was a very short trip.

Senator LOTT. Well, I'm sorry I wasn't there. I was in Bratislava, Slovakia speaking to the NATO enlargement meeting there, which was an interesting experience also, but we're glad that you were there and it went well.

Mr. O'KEEFE. Thank you, Senator.

Senator LOTT. The question I continue to have in my mind when I look at your budget requests and for the next fiscal year and through 2009, you say that you'll add $12.6 billion for the exploration initiative, of which $1 billion only is new funding and the rest of it, $11.6 billion is redirected from other activities. I still am very leery of that. I think we should put more new funding into it, because when you start redirecting all this money, you're going to be taking away from some good programs. Some probably have seen their better days and some that the money could be better used, but I'm not sure we're getting very much here, because you're going to be resisted in that by a lot of us and you may not get the money the way that you're asking for.

How do you respond to the fact that your $11.6 billion is supposed to come from these other activities?

Mr. O'KEEFE. Yes, sir. Well, what the attempt in this chart is to display is that it is a transformation of what we're involved with. For example, one, the biggest major item in that $11½ billion is a year ago we were projecting roughly $6 billion to go to the orbital space plane. Now we're projecting about $6½ billion to go to Project Constellation, the crew exploration vehicle. So more than half of that difference is just the movement of the funding that was intended for the orbital space plane, which would only be point-to-point transit between here and station, and instead transitioning that same asset level and more toward the Project Constellation effort to go beyond low-earth orbit, past station, and continue on.

And it is an array of other things that I could identify for the record for you that really make up that difference.

Senator LOTT. Have you already done that in earlier questioning?

Mr. O'KEEFE. Yes, sir, but I'd be happy to provide that for the record for you as well.

Senator LOTT. That's all right. If you've already done it, we'll get access to it.

Mr. O'KEEFE. Yes, sir.

Senator LOTT. One of the things that worries me, as you look to the future also, is the infrastructure upgrades that we need. As you know very well, you've seen since you've took over as administrator, we've starved a lot of that. We have not been doing infra-

structure upgrades the way we need to. A lot of it is old and we're going to need to upgrade it to more modern capabilities. You do have some money for that in 2005, right?

Mr. O'KEEFE. Yes, sir.

Senator LOTT. That will go into things like fire security and medical emergency operations, emergency energy management, things of that nature? Is that correct?

Mr. O'KEEFE. Yes, sir.

Senator LOTT. And then you got to jump over that and go to the next problem, which is upgrading the utilities services and the propulsion test facilities, RP fuel capability. What are your plans on that?

Mr. O'KEEFE. Offhand, I don't recall off the top of my head, but let me get you some——

Senator LOTT. Well, I'd like it if you would submit that for the record.

Mr. O'KEEFE. Yes, sir, I'd be delighted.

Senator LOTT. Now, another area is, over the last 2 years, NASA headquarters had redirected earth science application programs away from development of commercial remote sensing capabilities toward developing applications to serve mission needs of other Federal agencies. Is that correct?

Mr. O'KEEFE. Frankly, sir, we've attempted to make the information as broadly available as possible, and so therefore have emphasized an all-source, all-access availability of the earth science data, and that's more the approach we're using.

Senator LOTT. I'd like for you to provide for the record how much has been redirected to other Federal agencies and are they paying for it.

Mr. O'KEEFE. Yes, sir. I'll provide a more extensive——

Senator LOTT. Do you think they're paying for it?

Mr. O'KEEFE. Sure. The approach we're using now is we deploy and operate—I'm sorry, we deploy the NOAA satellites, for example, they pay for the operations and continued activities to——

Senator LOTT. I just want to make sure that they're not getting a sweetheart deal from NASA, who's been kind of starved for money, now you're doing work for them and they are not paying for it. Let's make sure that whatever they get, other Federal agencies, that they are paying for it.

Mr. O'KEEFE. Secretary Evans thinks he's carrying his weight on that, there's no doubt about that, and we agree.

Senator LOTT. For years I have worked to try to make sure that all this knowledge we get from NASA exploration across the board, science and medicine and technology gets into the private sector, and that wasn't a natural movement for NASA, it just hasn't been the way they thought. We made some progress in that area, but now it looks like you may be looking at it in a different way, instead of spin-off technology you want spin-in programs.

I hope that you'll continue to pay close attention to the need to make what you learn available to the private sector, because that is critical, I think, for development in the United States and it's a terrible waste if we just keep it in-house in NASA or other similarly active technology-developing Federal agencies.

Mr. O'KEEFE. Yes, sir. I concur entirely. Our approach really has to be to continue to help facilitate that, but with the major focus of realizing we aren't particularly equipped to figure out the market demand requirements and its applications as well as the private sector is. So our approach is really to try to determine how to make everything we have as broadly available as we possibly can, and that should have little, if any, limits to it. I'm constantly amazed every time I hear of any limitation on that point, because we ought to make it as broadly available as possible and have the private sector make determinations of how it can be applied to meet market demands they see. That really is the way to facilitate that best and it's one that I think is most consistent with the general philosophy that the administration is attempting to advance.

Senator LOTT. Are you cutting technology transfers at all?

Mr. O'KEEFE. The debate that within the Administration overall, and has been a continuing effort that as Administration policy is to, again, avoid setting up specific offices for the purpose of trying to identify technologies that need to be inserted into some market condition, and instead, using the technologies we develop to make it broadly available.

So what we're trying to do is refocus the attention of technology transfer efforts toward making a much broader availability of all of the technologies to as wide a business base as we possibly can, and that's the approach that we're looking to rather than to diagnose how——

Senator LOTT. Does that mean you're going to try to make that here in Washington?

Mr. O'KEEFE. No, sir. It's happening at each of the individual centers and across the—as a matter of fact, we're trying to minimize the amount of activity here in D.C.

Senator LOTT. Good. I'll ask you again, are you cutting technology transfer funds?

Mr. O'KEEFE. No, sir, I don't believe so, but let me get you—in terms of what the relative dollar amount year to year is I'd have to take a look at it.

Senator LOTT. I'd really like to see that, because to the average man out there on the street, when the President said let's go to Mars, it didn't go over real well. And then if you add to that, well, we're going to go to Mars but we're going to cut a technology transfer into the private sector where people can benefit from that technology, that knowledge and create jobs and make money off of it, that won't sell.

Mr. O'KEEFE. Sure, and that's not our intention at all.

Senator LOTT. But let's—when we're—if you go to this—I've always supported NASA and I can't think of many NASA programs I haven't always backed, but as you take this next quantum leap, let's don't leave the good stuff behind, and that's going to be a real challenge, because you're going to have a hard time doing that with the amount of money that you get in the budget and from the Congress.

Mr. O'KEEFE. Indeed. Thank you, Senator.

Senator LOTT. Do you have some more questions, Senator Nelson? Thank you for being here, Mr. Administrator.

Mr. O'KEEFE. Thank you, Senator. It's a pleasure to be with you.

Senator NELSON. Senator Lott, before you got here, there was a comment that would bear directly on what you said, and I agree, the average man on the street, you say, let's go to Mars and they don't relate to that. They certainly would if they understood the development of that technology as it applies to their daily lives, as it enhances the quality of their life and so forth.

There's one other factor that can really make a difference, and that is what we talked about earlier. If these Mars explorers, now after this phenomenal finding that there in fact was water on Mars, and if the future explorers in 2007 and 2009 and 2011 suddenly add to that that in fact discover that there was some form of life, then I think you're going to get generated a whole new enthusiasm back on planet Earth to want to find out was that life developed, and if it was, was it civilized, and if so, what happened to it?

Senator LOTT. I think it went to Roswell, New Mexico, didn't it?

Senator NELSON. You know some people said that when we went to the moon were they just roaming around on the surface of Arizona or New Mexico. But what then would occur, I think, would be a new emphasis, a new push to get a human up to Mars so that you can have human judgment as the human goes about exploring what happened and was there life and how developed it was.

So we've got some exciting times ahead of us especially in light of the discovery just within the last 2 weeks about water on Mars.

Mr. O'KEEFE. To your point, I think that's precisely the right focus is what we've now seen is more conclusive evidence that the atmosphere, the climate, and the material condition of that planet was substantially different at some point in the not-too-distant past.

Senator NELSON. And, Mr. Chairman, this wasn't little drops of water. What the evidence is that there were huge oceans of water and that kind of starts to remind you about our own planet. And so if it was, what happened to it and how can we learn to be better stewards of what we have if something similar happened to Mars millions of years ago.

Now, I hope you're right, Mr. Administrator, that the development of this crew exploration vehicle, as you call it spirals, would have such phenomenal success that you would suddenly have this thing developed and man-rated by 2010 or 2011 to follow on when you are planning to retire the Space Shuttle. But the likelihood looking at history is that it'll go the other way. We thought, for example, after we flew Apollo-Soyuz in 1975 that we were going to be launching the space shuttle in 1978, and of course it didn't occur until 1981.

And so if you do have this longer hiatus, then the question is begged to be asked, can we rely on European rockets and Russian rockets in order to do all the things that we want to do on the Space Shuttle, I mean on the space station, until such time as we get this crew exploration vehicle developed and ready to fly? You want to comment on that?

Mr. O'KEEFE. Yes, sir, thank you. It's a very challenging problem that we're looking at it, there's no doubt about it. It really turned on this point. Either we built a program that would be contingent completely on success at every interval, or put together a realistic

program that was probably more conservative that it needed to be in order to really look at this question and tease out an answer to it.

And in my mind, the responsiveness of our partners throughout the course of the, since the *Columbia* tragedy, has been a testimonial to the fact that we have a depth of this partnership that may well sustain us through any of these challenging periods that may create a gap. We're going to need to work as a partnership though, there's no doubt about it, and that's something that the other partners in the international space station arrangement have stepped up when we needed it most, has demonstrated the depth of it. It has not cost us additional amounts in order to do this. They've all been willing partners in that engagement.

And I think the answers to this set of questions, and I think they're the ones we have too, will be much clearer and easier to understand in the time ahead when we renegotiate the agreements that extend through 2006 on what the partners will all be responsible for in terms of crew transfer and crew return vehicle requirements, and that's something we're going to be dealing with here in the months ahead is actually reaching understandings about those broader arrangements in that intervening period of time and between now and then.

There's an awful lot of opportunity now to use and consider not only shuttle for a continued construction of station, but also a different configuration potentially of other crew transfer Soyuz capabilities in order to facilitate a larger crew size, more frequent, a varying crew size depending on what the expedition crew requirements may be. So that's going to get clearer here in the time ahead, but it is an issue that we've really got to sort through. There's no doubt at it, it has those implications.

Senator NELSON. Give us an update on the Shuttle priority upgrades and the Service Life Extension Program.

Mr. O'KEEFE. The approach we've taken is to, attendant to the President's announcement that we fly the shuttle through completion of international space station with the objective of accomplishing that goal by the end of the decade, is we've converted the service life extension program effort focus toward one that is now more dominantly focused on—not exclusive focused on—safety upgrades necessary to sustain activities through the end of its service life, as well as those modifications that we can do now, given the fact we've got this hiatus period in which we can implement those capabilities that improve its efficiency as well as, again, improve the safety standards that are necessary to continue flight after we return to flight.

And so that effort has converted from, give us the modifications it will require or give us the opportunity for longer service life, to ones that are now focused very dominantly on what can we do to assure safety standards consistent with the board recommendations and improve efficiency between now and the point in which we retire it.

Senator NELSON. What is your plan to keep experienced and skilled workers as you transition from the shuttle to this crew exploration vehicle?

Mr. O'KEEFE. This is going to be a challenge. It's one that we need to work through, and I think again one of the real virtues of the acquisition strategy we've tried to put in motion here for the Project Constellation is the development of several, much like Mercury, Gemini, Apollo, looking at several spirals in that process to demonstrate capabilities, and looking at something as early as 2008 as the initial deployment of components of Project Constellation will inform us a lot more in terms of how much of a transition we can achieve between the conclusion of the shuttle activities and operations and over to continued activities under Project Constellation.

So the earlier we're able to develop that first set of spiral development capabilities and components, the sooner we'll have an answer I think in terms of how that workforce shifting occurs and where the skill mixes are you need for launch services, continued servicing activity, operations, all the things that are necessary there at the launch complexes.

Senator NELSON. Thank you.

Senator LOTT. I believe that's all, Mr. Administrator. Thank you for taking the time to be with us this afternoon and we'll look forward to getting these further answers from you and working with you in the future.

Mr. O'KEEFE. Thank you, Mr. Chairman. I appreciate it very much.

Senator LOTT. The meeting is adjourned.

[Whereupon, at 3:25 p.m., the hearing was adjourned.]

A P P E N D I X

PREPARED STATEMENT OF HON. ERNEST F. HOLLINGS,
U.S. SENATOR FROM SOUTH CAROLINA

There are three situations that confront us as we begin deliberation of NASA's FY 2005 Budget Request. First, we have a bold, new vision before us, but one that requires lots of trade-offs. Second, we have the circumstances of the Hubble Space Telescope decision that NASA made and that is now being reviewed by the National Academies of Science. Third, we have the reform of NASA and its safety culture. These three circumstances don't point us in the same direction, so we have to deliberate on what they mean.

The President's announcement on January 14 was long on vision, but very short on details—and the FY 2005 Budget Request before us today hasn't cleared up that problem.

We don't know much more than we were told on January 14. What we do know is that NASA now wants to cancel the Shuttle, limit U.S. involvement in the International Space Station that U.S. taxpayers built, build a new Crew Exploration Vehicle, and change NASA back to focusing almost solely on enabling human exploration of space. These are dramatic changes that challenge us to think about our Nation's future in space in new ways.

Of course, having a vision for NASA is good. For nearly three decades, NASA floundered with visions that didn't work, results that fell short of promises, and management execution that just made things worse. We'd like to think that having a new vision will change all that.

But as we seek to understand the few details we have, we are in a quandary. This budget says that in order to achieve this vision, we have to:

- Decide to stop flying the Space Shuttle and commit U.S. astronauts to flying on Russian space vehicles for many years to come;
- Interrupt and cancel billions of dollars of research in Earth science, high-energy physics, relativity physics, and solar research; and
- Have faith there's enough money in the budget to buy whatever is required, with no good idea what may be required or how much it will cost.

This budget reminds us that you can't fund "vision," you have to have a plan. And NASA tells us their plan is still six months or more away.

And so I am drawn to caution. In this year of tragedy and transition, we need to be careful not to play roulette with the U.S. Space Program. You can't sustain commitment to the U.S. Space Program by shutting it down, and you can't accelerate development while you are in a sustained lull.

Second, the decision to no longer service the Hubble Space Telescope is hanging in the air. We await the findings of the National Academies on this question, but I will add that if NASA is going to say that it can no longer support the Hubble because of risks to astronaut crew, then I'm not sure where we are headed on safety.

The *Columbia* Accident Investigation Board went out of their way to emphasize that the Shuttle was not unsafe and could be flown again; but they emphasized that the way NASA went about operating the Shuttle had to change. Now, NASA seems to be saying the vehicle is unsafe, and we can't take the risk of using it, except when it comes to completing the Space Station over the next several years.

It is not obvious to me that these conclusions are based on safety alone; there seems to be a separate clause of expediency that we haven't heard explained. We will need to have it explained before the Congress is going to enact any new budget or legislation authorizing new programs for NASA.

Third, we have the issues raised by the *Columbia* Accident Investigation Board about cultural changes at NASA that still have not been addressed well after the date when NASA first proposed to return the Shuttle to flight. NASA seems to be

dragging its heels on the Board's most important recommendation: establishing an Independent Technical Authority over Human Space Flight programs.

Juxtaposing this situation with the President's call to return to the Moon makes a stark contrast. The *Columbia* Accident Investigation Board called for a new space vision in the name of dedication and safety. Then an interagency panel met to assess all the pros and cons and all the benefits and risks of space flight and come out with a new and better approach to human space flight.

But where is safety in the new vision? Where is the calculation of measured risks relative to rewards that we expect to inform our debate.

Remarkable achievement in space is our National heritage, so we must remain open to possibilities, including the possibility that we will find new ways of dealing with the risks of space flight. But where is that approach in the President's vision and when will it be addressed?

Together, these three circumstances will set the outlines of our future debate: whether to adopt this new space vision despite its severe consequences and staggering lack of detail; what to learn from how NASA has measured risk and reward in its recent Hubble Space Telescope and International Space Station decisions; and how and if NASA has exhibited the capacity to change itself.

And each of these examinations will set the standards by which we will continue to judge the direction, quality, and merit of NASA as the agency makes its first, fledgling steps beyond the tragedy and errors of the past year.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN MCCAIN TO HON. SEAN O'KEEFE

Question 1. As you know, the *Columbia* Accident Investigation Board report found that NASA's focus on a February 19, 2004, launch date for Node 2 of the International Space Station "may well have subtly influenced" the way managers handled the foam strikes on STS–112 and the *Columbia.* The President has recently announced that he intends for America to complete its work on the Space Station by 2010. It is estimated that it will require 23 to 30 Space Shuttle flights to complete the Space Station. The next flight of the Space Shuttle is scheduled for the spring of 2005 at the earliest. Considering all of these factors, how do you intend to meet the President's time line, and still prevent the schedule pressure that played a role in the *Columbia* accident?

Answer. NASA will only resume flight of the Space Shuttle based on the recommendations of the CAIB once specific milestones have been met and will operate the Space Shuttle with an emphasis on safety, not schedule. NASA is developing its requirements for Shuttle missions keeping in mind the primary objective of completing construction of the Space Station, including the U.S. components that support U.S. space exploration goals and those provided by foreign partners, with the minimum number of Shuttle flights. NASA expects to be able to operate the Shuttle safely and complete the International Space Station consistent with the timetable established in the Vision for Space Exploration.

Question 2. The Fiscal Year 2004 Conference Report for the Omnibus Appropriations bill included 151 Congressional add-ons, which cost $388.2 million. How do these add-ons affect NASA's operations?

Answer. NASA's FY 2004 budget submission was developed based on the Administration's priorities. The $388.2 million in earmarks in FY 2004 were not funded as "add-ons." Rather, the earmarks displaced a total of $388.2 million in funding planned for ongoing science and technology programs through specified and unspecified appropriations reduction. Among the programs impacted are: Project Prometheus; the Space Interferometry Mission (SIM); Beyond Einstein mission; the Climate Change Research Initiative; the International Space Station (ISS); and the Space Launch Initiative. The $200 million reduction in the ISS program is especially burdensome. The ISS reduction could not be accommodated in funding for ongoing ISS operations, forcing the Agency to reduce program reserves by $200 million, and thereby placing at risk the steps taken last year to address recommendations of the ISS Independent Management and Cost Evaluation (IMCE) Task Force. Each and every project that is reduced because funding has been redirected toward earmarks must be re-evaluated, replanned, and rescheduled, with potential cost impacts.

In addition, the 151 earmarks represent activities that were not planned, causing a significant administrative burden on the Agency, in terms of review and evaluation of proposals required for earmarks, as well as the monitoring of implementation of earmarks. For example, 45 of the 151 earmarks are managed by NASA's Education Enterprise, at a value of $62 million, equivalent to approximately one-third

of the base budget of the Education Enterprise; management of this number of earmarks imposes a very great burden upon Education Enterprise personnel.

Even the earmarks that are intended to augment ongoing Agency programs can cause a significant amount of added work. As a result of such programmatic earmarks, projects included in the budget request must change their scope to be commensurate with the new funding levels. This can cause an entire project to change, often impacting other programs/projects. For instance, if additional funding is provided for a project and a schedule is therefore accelerated, that project may need to use a test facility sooner then planned, which may cause another project to get "bumped", causing the other project to replan its program.

Question 3. On January 16, 2004, you announced that you were canceling any future-servicing missions of the Hubble Space Telescope. You have stated your rationale for this cancellation.

On March 17, 2004, you wrote a letter to Dr, Bruce Alberts, the Chairman of the National Research Council and the National Academies of Sciences, requesting assistance in ensuring that NASA has considered all reasonable alternatives to this objective. What results do you expect to get from this letter?

Answer. The decision to cancel any future HST Shuttle Servicing Missions was based on a very deliberative investigation of the safety issues involved with going to HST's unique orbit and in adhering to the recommendations of the *Columbia* Accident Investigation Board. Members of Congress, while understanding the rationale of not putting our astronauts in a position of undue risk, asked that NASA engage the National Research Council to conduct an outside review. They have agreed to do this and we look forward to their thoughtful input.

Question 4. One of the recommendations of the *Columbia* Accident Investigation Board is that NASA develop the "capability to inspect and effect emergency repairs to the widest possible range of damage to the Thermal Protection System" of the Space Shuttle, including the tiles and Reinforced Carbon-Carbon panels. What is the status of the research being done to implement this recommendation?

Answer. NASA has made significant progress in developing credible tile repair processes and materials. An existing, silicone-based, cure-in-place ablator has shown positive results in development testing. A manufacturing process change appears to control a foaming problem observed during early vacuum tests. The material adheres to aluminum, primed aluminum, tile, strain isolation pads, and tile adhesive in vacuum and cures in a vacuum. This tile repair material has now transitioned to characterization and qualification testing. Detailed thermal analyses and testing are under way to confirm that this material can be applied and cured in the full range of orbit conditions. Additional arc jet, radiant heating, thermal-vacuum, and KC–135 zero gravity tests are scheduled to confirm that this material will survive the entry environment when applied using the proposed repair techniques. Assuming the continued testing of the existing ablator is successful, the tile repair materials and tools should be ready in the December 2004-March 2005 timeframe.

The RCC repair effort is still in the concept definition phase and is much less mature than the tile repair material study. The RCC repair project is pursuing three complementary repair concepts that together will enable repair of a wide variety of potential RCC damage: Plug Repair, Rigid Wrap Repair and Crack Repair. Plug Repair consists of an insert intended to repair holes in the wing leading edge (WLE) with sizes from 1/2″ to 4″ in diameter. The Rigid Wrap is a complete over wrap for a given RCC panel intended to repair any catastrophic damage detected on the panel. Crack Repair uses a material application to fill cracks and small holes in the WLE. All three concepts are expected to have limitations in terms of damage characteristics, damage location, and testing/analysis. Schedules for design, development, testing, evaluation, and production of these concepts are in work and we are evaluating the concepts across six NASA centers, 11 contractors, and the United States Air Force Research Laboratory.

Question 5. On March 27, 2004, NASA's X–43A broke the flight speed record by reaching a hypersonic flight and a top speed of 5,000 miles per hour before being intentionally ditched in the sea. According to a March 29 article in *Space News,* NASA is looking at canceling the X–43C, which is a follow-on to this program. What are your thoughts about the future of this program?

Answer. As a result of the success of the X–43A Mach 7 flight, we are planning to fly another hydrogen-fueled X–43A at Mach 10 in September 2004.

With the establishment of the National Aerospace Initiative by the Department of Defense (DOD), NASA aligned its follow-on hypersonics research (known as the Next Generation Launch Technologies (NGLT) Program) as a partner in the initiative. NASA's mission need for access to space served as the primary basis for continued research, while DOD's interest was in a weapons platform. In January 2004,

The Vision for Space Exploration was announced. Since the Vision for Space Exploration does not rely on air-breathing propulsion for access to space, NGLT work has been redirected. As a result, NASA has informed the Department of Defense that it will not be able to provide resources for the X–43C. The DOD is building the hydrocarbon-fueled ram/scramjet for the vehicle and NASA was to build the airframe. The DOD will determine the future of the X–43C program.

As to the future of hypersonic research within NASA beyond the X–43A Mach 10 flight, NASA is examining the scope and purpose of the hypersonic activities and priorities vis a vis NASA's current aeronautics research.

Question 6. The Crew Exploration Vehicle is now estimated to cost $24 billion to build and operate. What steps do you intend to take to control the development costs for the Crew Exploration Vehicle?

Answer. There are three critical issues necessary to control development costs of complex systems like the CEV: first is the generation and control of requirements; second an evolutionary acquisition strategy that enhances the ability to estimate cost while allowing technology maturation program to flow into future development spirals; and third, effective program control using earned value and risk management tools to closely track contract performance.

The requirements process is the key to the formulation of a sound program. An integrated NASA process for generating Level 0 requirements based on the Vision for Space Exploration has been developed. A rigorous approach to the development of Level 1 requirements is in place. To minimize costly requirements changes downstream, the requirements process includes users, technologists, engineers and operators (astronauts). The process also incorporates extensive modeling and simulation of the integrated system to identify capability gaps that will be the basis of the risk management process. In addition, it maximizes the input of industry, academia, and the NASA centers through Broad Agency Announcements (BAA) to generate concepts, identify risks, and determine technology leaps that will influence updated requirements prior to initiation of CEV development.

Question 7. What steps is NASA taking to develop these new capabilities (launch)?

Answer. NASA has initiated studies to evaluate concepts for crew and cargo launch vehicles for human exploration missions, including existing and evolutionary concepts based on the Evolved Expendable Launch Vehicle (EELV). Follow-on studies will address launch system capability of the human-rated CEV. These studies will determine the acquisition strategy for launch and will be integrated into the overall systems acquisition strategy for exploration missions.

Question 8. China recently announced its plans to move up the launch date of its moon orbiter to 2006. What effects do the space exploration plans of countries like China and India have on NASA's space exploration agenda?

Answer. The President directed NASA to pursue international cooperation in implementing the Vision for Space Exploration. Where other nations have exploration plans that complement the work NASA will pursue, and where cooperation serves broader U.S. foreign policy goals, NASA will explore the potential for cooperative efforts. The vision itself was developed to serve U.S. national goals and was not influenced by the space activities or plans of other particular nations.

Question 9. NASA is also pursuing Project Prometheus, a program to develop a nuclear-powered orbiter that will search for evidence of oceans on Jupiter's moons: Europa, Ganymede, and Callisto. What is the status of this program?

Answer. A detailed status has been completed in response to a prior Congressional request and will be updated quarterly. The first quarterly Project Prometheus report has been forwarded to Congress. Enclosure 1

Question 10. What are the steps that NASA will take to address public concerns about the use of nuclear power in space?

Answer. Throughout its forty-year history, NASA has relied on nuclear energy to power a range of important exploration missions. To support a better understanding between policy makers and the public regarding nuclear energy and the important role it plays in space exploration, Project Prometheus has created the Communications, Engagement and Outreach (CEO) project. The CEO project is in an initial planning phase to establish mechanisms for exchanging information with the public and is committed to establishing clear, consistent, and transparent communications processes. The CEO project combines aspects of public affairs, risk communication and participatory public engagement strategies, and in addition, will rely on informal and formal education and public outreach efforts.

In this initial phase, NASA is working with The Keystone Center,[1] via a contract with Jet Propulsion Lab (JPL), to identify areas of public concern and to identify organizations that may take an interest in the program. In parallel, Project Prometheus is sponsoring workshops with experts in the fields of formal and informal education and public outreach to assess opportunities for public engagement in these areas. The results of these activities will form the basis of a long-term communications, engagement, and outreach plan.

NASA is considering options for engaging organizations and individuals in a dialogue that includes discussions of the technical risks presented by our use of complex technologies and processes. "Engagement in a dialogue" is a term of art that requires communicating an Agency's, or a program's, vision, goals, and specific near- and long-term plans, and in turn understanding the publics' issues, interests, and concerns. It is our hope that through such dialogue and mutual understanding that effective programs and processes can be developed to increase public confidence in why and how we intend to meet our objectives. For Project Prometheus, this means increasing public understanding of, and confidence in, space nuclear power and effectively addressing concerns about our safety and risk management processes and, furthermore, requires establishing clear and transparent decision-making and communications processes.

Through the CEO project, NASA intends to establish a regular dialogue with interested organizations and individuals, to listen to and better understand public opinions and concerns, and to share our goals and plans.

Question 11. The current schedule for the return to flight of the Space Shuttle is next year. If that schedule slips, it makes it more likely that NASA will not be able to complete the assembly of the International Space Station by 2010. The *Columbia* Accident Investigation Board report calls for a re-certification of the Space Shuttle orbiters if the are operated beyond 2010. Do you have any estimates of the cost of such a re-certification?

Answer. NASA is dedicated to safely meeting the Vision for Space Exploration's planned timetable that would complete assembly of the ISS and allow the Space Shuttle to be retired by the end of this decade. However, it is prudent for the Agency to develop contingency plans, so we are reassessing the need to recertify Space Shuttle systems, subsystems, or components based on alternate timetables of the phase-out of the Shuttle program. The technical work required to determine when and if recertification is needed will continue into this summer. Once the technical definition of the recertification tasks is completed, cost estimates will be developed on the items we would need to recertify and these estimates will be made available for discussion.

Question 12. The *Columbia* Accident Investigation Board report called for the establishment of a Technical Engineering Authority. It is not clear where the funding for this function is located within the FY 2005 budget request. Can you identify where in the budget request this organization would be funded?

Answer. In the FY 2005 President's Budget, funding for the new independent Technical Engineering Authority (now referred to by NASA as the Independent Technical Authority, or ITA) is currently included in the various Program/Project budgets. To implement the *Columbia* Accident Investigation Board's (CAIB's) recommendation for independent authority of the ITA, while maintaining an appropriate level of accountability within the program, NASA is planning to provide resources to our engineering and safety and mission assurance organizations that perform ITA tasks through an ITA/Safety and Mission Assurance (SMA) Service Pool. (Service pools are full-cost accounting mechanisms to charge support services to programs and projects based on consumption.) The final decision on the level of funding in the ITA/SMA Service Pool for each project will be determined outside of the program manager's decision authority, as recommended by the CAIB. The NASA Centers are currently determining resource needs for the ITA/SMA Service Pool as part of the FY 2006 budget planning cycle, with the goal of activating the new service pool in October 2004 for the FY 2005 accounting year. Funding for the service pool will be reallocated from existing programmatic budgets once this proposed response to the CAIB's recommendation has been developed to a level that is satisfactory to NASA, and has been reviewed with the various independent organizations involved (including the Stafford-Covey Return to Flight Task Force, the Aerospace Safety Advisory Panel, the NASA Inspector General, and Congress itself). Although the de-

[1] The Keystone Center is a non-profit, independent mediation and facilitation organization, founded in the 1970s that uses scientific reasoning, analytic frameworks, and alternative dispute resolution techniques to build consensus and sustainable policies. The Keystone Center has been on contract to JPL to provide information and facilitation services for the Mars program, and expanded its contract at the request of NASA HQ, to include Project Prometheus.

gree to which additional costs may be attributed to the ITA is highly dependent on the detailed approach that will serve to implement the CAIB's recommendation, the approach presently being developed and implemented is not expected to require significant additional resources.

Question 13. The *Columbia* Accident Investigation Board report cited cultural problems are equally responsible for the *Columbia* accident as the technical causes. How much progress has NASA made in resolving the cultural issues identified in the report?

Answer. *Background:* NASA had begun to address issues of "culture" before the *Columbia* accident. Even as the 2002 Federal Human Capital Survey results identified NASA as one of the best places to work in the Federal Government, a grassroots effort was underway to explore issues within the NASA culture that, if addressed, could improve the Agency's effectiveness and performance.

In July 2002, a team of NASA and contractor employees began working to assess the feasibility and define the action plan needed to create a more highly unified NASA organization. This One NASA team set out to formulate a set of specific recommendations for organizational and cultural change, emphasizing teamwork and collaboration across the Agency, which would elevate NASA to a new level of effectiveness and performance.

The CAIB issued its report in August 2003, a mere 7 months after the tragic loss of *Columbia* and her crew, and found that NASA's history and culture contributed as much to the *Columbia* accident as any technical failure. This is explicitly identified in the Organizational Cause Statement found in Chapter 7 of the report. This chapter gave us a very candid look into our organizational culture and provided us with a great opportunity to take a deeper look our culture, to look at those aspects that are positive and also those that need improvement, and to take action to achieve positive, long-lasting change at NASA.

Progress and Actions

Safety Climate and Culture Survey

Based upon the CAIB report and our desire to place even greater attention on moving to a more effective culture, we felt it would be beneficial to engage external expertise to assist us in developing and deploying an organization plan for culture change at NASA. To this end, on February 9, 2004, NASA awarded a contract to Behavioral Science Technology, Inc. (BST), an organization with specific expertise and proven track record helping organizations achieve safety excellence through culture transformation and leadership development.

The first part of BST's effort involved establishing a baseline of our culture by administering a Safety Climate and Culture Survey. BST delivered the final survey results, along with a recommended implementation plan for NASA to achieve positive improvements in its culture, in a report entitled, *Assessment and Plan for Organizational Culture Change at NASA,* which is available on the NASA HQ website (*http://www.nasa.gov/about/highlights/index.html*).

The results of the survey support NASA's legacy of technical excellence, teamwork, and pride, indicating that we are strong in areas such as teamwork, work group relations, approaching coworkers about safety concerns, and reporting incidents or deviations that affect safety. The survey also identifies important safety and organizational issues that must be addressed before we can initiate positive changes within the agency. There is a general perception that the organization as a whole does not show concern for the needs of employees. There is also a perception that there are deficiencies in the quality and quantity of upward communication about safety issues.

While these issues are similar to those highlighted in the *Columbia* Accident Investigation Board Report, this *Assessment and Plan for Organizational Culture Change at NASA* has given us specific data to assess organizational functioning down to the directorate level, as well as a specific plan of action for improving these aspects of our culture.

Implementation Plan

One of the first steps of this plan will be for the core leadership team to validate and embrace NASA's Core Values. These values will drive the culture change effort. The plan also calls for focused change-related activities to take place at specific Centers and Directorates, with the aim of achieving measurable results in five months.

These activities will first take place at Glenn Research Center, the Engineering and Mission Operations Directorates at Johnson Space Center, the Safety and Mission Assurance Directorates at Goddard Space Flight Center and Kennedy Space Center, and at Stennis Space Center. Activities at these locations will include leadership practices assessments, development of individual action plans for Center

leadership, behavioral observation and feedback, and behavior-based project team effectiveness training.

Additionally, in the next months, BST will assist each Center in developing Center-specific implementation plans to achieve positive cultural improvements, driven from NASA's core values, while accommodating the unique needs of each Center. At the end of five months, we will use specific data and feedback to determine if measurable progress has been achieved, including whether NASA leadership has adopted behaviors that support the desired culture. Once measurable progress has been achieved and the processes used to achieve forward progress have been validated, NASA plans an agency-wide deployment of the above-mentioned approach.

In addition to specific implementation steps we can undertake to achieve positive change in our culture, the plan also emphasizes the need for a single culture change initiative that integrates existing activities where appropriate but minimizes the proliferation of multiple approaches, philosophies, models, methods, and terminology. This culture change effort that NASA is undertaking will serve as an integration point to ensure that all the Agency's ongoing efforts related to culture change are aligned in a manner conducive to a comprehensive organizational culture change.

Question 14. You mentioned in your written statement that NASA provides $100 million to the Climate Change Science Program. How much NASA funding is provided for the U.S. Global Climate Change Research Program?

Answer. The U.S. Climate Change Science Program (CCSP) is composed of the U.S. Global Change Research Program (USGCRP) and the Climate Change Research Initiative (CCRI). The CCRI is designed to build on the long-term research of the USGCRP and accelerate progress in key areas of scientific uncertainty. NASA's FY 2005 Budget Request includes a total of $1.3 billion for the CCSP, $1.2 billion of which supports USGCRP activities. The remaining $0.1 billion (cited in the written statement) reflects NASA's proposed contribution to the CCRI.

Question 15. Can you update the Committee on NASA's use of the authorities granted to the agency by the recently passed NASA Flexibility Act of 2004?

Answer. The Act requires NASA to submit to Congress a written plan (the Workforce Plan), approved by the Office of Personnel Management, 90 days prior to exercising the new authorities. The approved Workforce Plan was provided to the appropriate committees of Congress, including the Senate Commerce Committee, on April 8, 2004. Therefore, NASA will be able to exercise the authorities in the Act as of July 8, 2004.

To ensure that the Agency is prepared to use the new flexibilities effectively and that employees are well informed about them, NASA has been actively engaged throughout the past several months in providing information regarding the Act to employees, managers, and employee representatives through a variety of media.

The authorities in the NASA Flexibility Act of 2004 will provide NASA with critical tools for recruiting and retaining a world-class, diverse workforce, and we appreciate the Committee's support of this legislation.

Question 16. You recently wrote Senator Bond concerning the number and amount of Congressional earmarks. How important is it that these earmarks are minimized to the future success of the agency?

Answer. Recognizing the significant challenges faced by Congress regarding fiscal responsibility in an environment in which discretionary resources are highly constrained, and NASA's efforts to align the Agency's budget to achieve the goals and objectives of the Vision for Space Exploration, it is incumbent upon the Congress and NASA to work collaboratively to execute an effective and productive NASA budget for FY 2005 and beyond. It is critical that earmarks be minimized so as to avoid displacing funding for ongoing and proposed science and technology programs, resulting in schedule slippage and cost growth. It is also critical that earmarks that are included in annual appropriations action be meritorious as well as consistent with, and in furtherance of, NASA's mission.

Question 17. You have mentioned in your written statement that the approach to the new vision for exploration is intentionally flexible, with investments in sustainable exploration approaches to maintain affordability. What does that mean?

Answer. The Vision for Space Exploration provides the guiding principles for a sustained and affordable exploration of our Solar System and beyond. It defines objectives for a robust space exploration program, and tasks NASA to develop programs and plans to implement this vision. The vision will require a collection of new programs, some near term, and others to be developed in the future. With each step, as we build, test and then explore, we will learn more about the challenges to overcome as we continue our exploration vision. We then exercise the flexibility in future

programs to update requirements with what we have learned. This is the core of what we have described as the spiral development model.

To ensure that each program contributes to a sustainable approach for exploration, we are developing an over-arching framework of requirements and architecture to guide the development of individual programs. These requirements and architecture will be used to ensure that individual programs are not just optimized to meet their own requirements, but also consider the requirements of the longer-term vision. We intend to develop capabilities that are not optimized for single mission scenarios, but are robust enough to support the exploration decisions to be made in the future.

Regardless of the direction taken, NASA is committed to pacing achievement of the exploration vision with reasonable budgetary increases; in the outyears the plan is to pace progress with budget increases based only on inflationary growth.

Question 18. When will the Congress have a better estimate of the costs of the new exploration initiative?

Answer. Based upon re-aligning priorities and retiring the Space Shuttle, with the requested additional resources provided in the near term, NASA believes that the programs required to implement the new vision can be accomplished within expected future budget levels. The new initiative is in fact a long-range vision to be comprised of multiple programs and projects, many of which will be formulated only after gaining knowledge and experience from preceding programs and projects. For this reason, it is not possible to offer a meaningful total cost estimate for this long-term initiative, but as NASA establishes specific requirements and develops the details for each program within this long-range vision, costs baselines for each program will be established and provided to Congress.

ENCLOSURE 1

FY 2004 PROMETHEUS QUARTERLY REPORT THROUGH MARCH 31, 2004

Prior to the January 2004 reorganization of NASA, Project Prometheus, comprised of the following three program elements, was managed within the Space Science Enterprise:

- Nuclear Power (Radioisotope Power System (RPS) Research and Development)
- Jupiter Icy Moons Orbiter (JIMO, Mission Development)
- Nuclear Propulsion (Technology Research)

Following the establishment of the Exploration Systems Enterprise, the last two program elements listed above were moved under the management responsibility of this new Enterprise. The Radioisotope Power System (RPS) Research and Development activity remains in the Space Science Enterprise, as does the new element related to Jupiter Icy Moons Orbiter science. However, NASA still views Project Prometheus as representing all facets of NASA's space nuclear power and propulsion development efforts. Therefore, this report contains information on the following program elements, the first and last of which reside in the Space Science Enterprise, while the others are managed by the Exploration Systems Enterprise:

- Radioisotope Power System (RPS) Research and Development *(Space Science Enterprise)*
- Jupiter Icy Moons Orbiter Mission *(Exploration Systems Enterprise)*
- Multi-Mission Space Nuclear Power and Propulsion Research Technology *(Exploration Systems Enterprise)*
- Advanced Space Nuclear Power and Propulsion Research Technology *(Exploration Systems Enterprise)*
- JIMO Science (Definition and Instrument Development) *(Space Science Enterprise)*

This report includes milestones and budgets in accordance with the President's five year budget request, is organized by program element and includes (1) objective, (2) budget, and (3) milestones.

The attached report provides program milestones and funding paths for Project Prometheus for the five years starting with FY 2005. Costs estimates and associated milestones for the next ten years are still being developed. NASA separates "missions in formulation" (such as JIMO) from those that have passed the appropriate definition phases and reviews, including independent cost review, non-advocate review, and preliminary design review, that are required for a mission to be consid-

ered "in development." Experience has shown that cost estimates are unstable during the initial definition and design phases of a project, as the details of the project are developed in preparation for the preliminary design review. Conducting a non-advocate review and confirmation review before committing to the project's composition, cost estimate, and schedule, is considered important to developing a reliable life cycle cost estimate. Under this somewhat new practice at NASA, a project's life cycle cost estimate is not considered firm until the completion of these activities.

FY04 Presidential Budget as enacted (FY04) and as submitted (FY05–08)

Program Element	FY04 (Request)	FY04 (Enacted)	FY04 (Op Plan)	FY05	FY06	FY07	FY08
Nuclear Power (Radioisotope Power System Research and Development)*	55.7	47.4	19.8	70.9	56.4	60.3	59.3
Jupiter Icy Moons Orbiter (JIMO, Mission Development)	92.6	87.1	84.0	308.1	491.1	574.5	603.9
Nuclear Propulsion (Technology Research)	130.9	123.2	116.9	168.2	164.6	107.9	108.1
Total by FY	279.2	257.7 (includes $1.3M rescission)	220.7	547.2	712.1	742.7	771.3

FY05 Presidential Budget Submittal

Program Element	FY05	FY06	FY07	FY08	FY09
Nuclear Power (Radioisotope Power System Research and Development)*	70.9	56.4	60.3	59.2	60.8
Jupiter Icy Moons Orbiter (JIMO, Mission Development)	229.0	250.0	270.0	290.0	310.0
Nuclear Propulsion (Technology Research)—Electric Propulsion (contained in Code S budget)	208.0 10.0	179.0 25.0	155.0 42.3	136.0 42.5	114.0 42.2
JIMO Science (Definition and Instrument Development)	12.5	25.0	25.0	25.0	25.0
Total by FY	530.4	535.4	552.6	552.7	552.0

*Multi-Mission Radioisotope Thermoelectric Generator activities are contained in the Mars Program budget within Code S and are not reflected in this table.

Radioisotope Power System (RPS) Research and Development

Objective

Reestablish and strengthen NASA's capacity to conduct science-driven, long-lived solar system and planetary surface exploration using radioisotope power systems by providing NASA space science and exploration mission planners with reliable, long-lived, rugged power sources, from milli- to multi-hundred watt.

This program element is comprised of the following four activities:

1) Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) Development
2) Stirling Radioisotope Generator (SRG) Development
3) Advanced Radioisotope Power Conversion Research
4) Purchase Plutonium-238 from Russia for civil use

Accomplishments Through March 31, 2004

- FY02—Competitively awarded development contract for Stirling Radioisotope Generator (SRG) to Lockheed Martin.
- FY02—Initiated testing of Stirling technology demonstration convertors at NASA Glenn Research Center.
- FY03—Competitively awarded development contract for Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) to Boeing Rocketdyne, supported by Teledyne Energy Systems.

- FY03—Competitively awarded 10 Power Conversion Technology Research contracts (Sunpower/Boeing, Creare Inc./Boeing, Teledyne (2), Creare Inc., Massachusetts Institute of Technology, Edtek, Cleveland State University, Essential Research, Hi-Z).
- FY03—Completed Preliminary Design Review of SRG Engineering Unit.
- FY03—Established new contract with Russian government for purchase of 15 kg of plutonium-238 (Pu-238) over next 5 years with an option for additional 15 kg.
- FY04—Placed order for 5kg of Pu-238 from Russia.
- FY04—Completed Preliminary Design Review of MMRTG Engineering Unit
- FY04—Held Phase 1 midterms for 10 Power Conversion Technology Research contracts.
- FY04—NASA Glenn Research Center Stirling power test converter exceeded 5,000 hours of continuous operation

1) Multi-Mission RTG (MMRTG) Development

Objective: Develop thermoelectric-based power units capable of operating in space and on planetary bodies with atmospheres.

Milestones:

- FY05—Complete Engineering model fabrication and tests.
- FY06—Complete Qualification Unit fabrication.
- FY07—Complete Qualification Unit tests.
- FY08—Complete first Flight Unit available for missions.

2) Stirling Radioisotope Generator (SRG) Development

Objective: Develop Stirling power cycle-based power units capable of operating in space and on planetary bodies with atmospheres.

Milestones:

- FY04—Hold Final Design Review.
- FY04—Complete Engineering model fabrication and tests.
- FY06—Complete Qualification unit fabrication and tests.
- FY08—Complete first Flight Unit available for missions.

3) Advanced Radioisotope Power Conversion Research

Objective: Develop advanced heat-to-electrical power conversion technology that would enable development of future radioisotope power systems with higher power, lower mass, and/or higher efficiency (reduced Pu-238 usage).

Milestones:

- FY06—Complete component testing and evaluation of technologies under the Power Conversion Technology Research contracts

4) Purchase Plutonium-238 from Russia for civil use

Objective: Procure adequate supplies of Plutonium-238 to meet NASA's space exploration requirements.

Milestones:

- FY05–FY08—Place order for 5 kg installments of Pu-238 (5 kg per year).

Jupiter Icy Moons Orbiter Mission

Objective

Enable significantly expanded scientific exploration, employing scientific investigations and instruments well beyond what is currently possible, of Jupiter's three icy moons, *Callisto, Ganymede, and Europa* by the middle of the next decade through the development and demonstration of the safe and reliable operation of nuclear space power and propulsion systems.

Accomplishments Through March 31, 2004

- FY03—Awarded three aerospace/nuclear industry study contracts (Boeing, Lockheed Martin, Northrop Grumman) for JIMO multi-mission spacecraft (Phase A).
- FY03—Formed government team of NASA and DOE personnel to study JIMO spacecraft and plan technology investments for multi-mission capability.

- FY03—Completed JIMO multi-mission space reactor conceptual design assessments.
- FY03—Formed JIMO Science Definition Team (SDT) to study the range of investigations of Jupiter and its icy moons made possible with the proposed JIMO system.
- FY03—Initiated feasibility study on high capability science instruments enabled by the JIMO system.
- FY03—Initiated annual high capability science instrument development program.
- FY04—Completed final report of JIMO Science Definition Team. The report included input on detailed science objectives, measurements, and requirements for the JIMO spacecraft and mission.
- FY04—Completed feasibility study on high capability science instruments for the JIMO mission.
- FY04—Initiated annual outer planets Research and Analysis program.
- FY04—Completed final report of JIMO Science Definition Team, including input on detailed science objectives for JIMO, and completed instrument concept study.
- FY04—Completed formal tasking of DOE-Naval Reactors to support Project Prometheus and JIMO
- FY04—DOE–NR initiated formulation of a development plan, schedule, and budget for the JIMO space reactor.

Milestones:

- FY04—Issue Request for Proposal for JIMO spacecraft.
- FY04—Complete feasibility study of simple landed science packages for the icy moons.
- FY04—Competitively award technology development contracts for high capability science instruments.
- FY04—Competitively award Research and Analysis contracts for outer planets research.
- FY05—Complete second phase of spacecraft technology trade studies and conceptual design by competing industry teams (3) and government team (NASA/DOE).
- FY05—Competitively select industry aerospace contractor for JIMO spacecraft.
- FY05 through FY07—Perform spacecraft preliminary design (Phase B).
- FY07—Initiate spacecraft detailed design (Phase C).

The former element, Nuclear Propulsion (Technology Research), now consists of two elements:

1) Multi-Mission Space Nuclear Power and Propulsion Research Technology

2) Advanced Space Nuclear Power and Propulsion Research Technology

Multi-Mission Space Nuclear Power and Propulsion Research Technology

Objective

Enable new classes of space science and exploration robotic missions not possible with current space propulsion and power systems, through the development of space nuclear reactor and electric propulsion technologies that would support the first flight mission enabled by nuclear electric propulsion. Technologies developed under this element will be, to the extent possible, multi-mission capable and applicable to near-term nuclear electric propulsion mission applications.

- Provide significantly larger amounts of power for electric propulsion, scientific instruments, and data return

This program element is comprised of the following three activities:

1) Multi-mission Power Conversion Research

2) Multi-mission Electric Propulsion Research

3) Multi-mission Nuclear Fission Reactor Research

Accomplishments Through March 31, 2004

- FY02—Completed Industry and Academia Request for Information on technologies for nuclear propulsion, and conducted industry briefings.

- FY02—Completed a series of detailed, in house (NASA and Department of Energy) mission studies, out of which emerged the Jupiter Icy Moons Orbiter.
- FY02—Competitively awarded 2 electric propulsion technology research contracts (NASA Glenn Research Center, Jet Propulsion Laboratory).
- FY03—Completed candidate reactor concept screening and conceptual design data packages for reactor concepts.
- FY03—Initiated technology research, development, and testing of a broad range of technologies for multi-mission JIMO spacecraft.
- FY03—Completed preliminary development-thruster unit design of the High Power Electric Propulsion (HiPEP—NASA Glenn Research Center) and Nuclear Electric Xenon Ion System (NEXIS—Jet Propulsion Laboratory) electric propulsion ion thruster systems.
- FY03—Initiated high-temperature materials and nuclear safety studies.
- FY04—Commissioned rhenium nuclear criticality benchmark measurements.
- FY04-Conducted integrated ion thruster test with 2 kWe Brayton power converter at NASA Glenn Research Center.
- FY04—Demonstrated first ion beam extraction and operation of NEXIS and HiPEP thrusters at power levels from 5–10 times greater and propellant efficiencies (*i.e.,* specific impulse) more than twice that of NASA's Deep Space 1 ion engine.

1) Multi-mission Power Conversion Research

Objective: Research and develop multiple high power (20–50 kWe) thermal-to-electrical conversion technologies for nuclear electric propulsion applications.

Milestones:

- FY06—Complete component level tests on Brayton and heritage thermoelectric systems.
- FY07—Complete Engineering Units for each system.

2) Multi-mission Electric Propulsion Research

Objective: Research and develop multiple high-power (20–50 kWe) electric propulsion technologies for nuclear electric propulsion applications.

Milestones:

- FY05—Complete component level tests on NEXIS and HiPEP technologies.
- FY06—Complete Engineering Unit on NEXIS and HiPEP technologies.

3) Multi-mission Nuclear Fission Reactor Research

Objective: Research reactor power systems suitable for planetary science applications and support development of test facilities, autonomous systems, and reactor fuel.

Milestones:

To be established by Department of Energy reactor developer.

Advanced Space Nuclear Power and Propulsion Technology Research

Objective

Study and develop advanced, large-scale space nuclear power and propulsion technologies that would enable more advanced. ambitious missions (both robotic and human) not possible with the space nuclear power and propulsion technologies developed for the first flight missions enabled by nuclear electric propulsion.

- Build upon technology developed for JIMO and follow-on missions to develop power and propulsion systems with the performance necessary for piloted vehicles to Mars and for other advanced exploration missions.
- Initial activities are geared towards development of surface-based power systems for robotic, human habitat, and in-situ resource utilization, and high-power in space propulsion systems that best exploit the potential of nuclear energy to expand our capacity to explore the solar system and beyond

This program element is comprised of the following four activities:

1) Advanced Electric Propulsion Research
2) Advanced Power Conversion Research
3) Advanced Fission Reactor Research
4) Advanced Nuclear Systems Concepts and Mission/Systems Analyses

Accomplishments Through March 31, 2004

- FY02—Competitively awarded 3 reactor power conversion technology research contracts (Boeing, Jet Propulsion Laboratory, Department of Energy's Oak Ridge National Laboratory).
- FY02-Competitively selected one electric propulsion technology research contract (Stanford University)
- FY04—Issued Advanced Electric Propulsion NASA Research Announcement.
- FY04—Issued Critical Issues in Electric Propulsion NASA Research Announcement.
- FY04—Conducted a workshop on past experiences with nuclear thermal propulsion.
- FY04—Created Team Prometheus mission analysis group to study robotic, surface power, human exploration, and sample return mission types.
- FY04—Completed design and fabrication of new high power (50 kWe) "400M" Hall thruster at Glenn Research Center.

1) Advanced Propulsion (EP) Research

Objective: Research and develop multiple advanced in-space propulsion technologies to include multi-megawatt nuclear electric and nuclear thermal propulsion.

Milestones:

- FY04—Select multiple technologies for near-term development through Advanced Electric Propulsion NASA Research Announcement process.
- FY04—Place contract, through Stanford University, for analysis of Hall thruster system.
- FY06—Complete component tests and evaluations of Hall thruster system.
- FY07—Complete component tests and evaluations for advanced electric propulsion concepts developed under Advanced NASA Research Announcement.
- FY09—Complete Engineering Unit tests and evaluations for promising alternate/advanced electric propulsion systems.

2) Advanced Power Conversion Research

Objective: Research and develop multiple high power thermal-to-electrical conversion technologies that would advance state-of-the-art technologies (factor of 2 to 5 improvements in converter reliability, lifetimes, power levels, and overall efficiency) in support of future nuclear electric propulsion and surface power applications.

Milestones:

- FY05—Complete component level tests on Brayton and Rankine dynamic power cycles, and the static segmented thermoelectric system
- FY06—Complete Engineering Units for each system
- FY09—Complete Engineering Unit tests and evaluations for advanced power conversion systems

3) Advanced Fission Reactor Research

Objective: Research reactor fuels and power systems of a high power level suitable for human and advanced robotic applications and support development of test facilities and autonomous systems for these applications.

Milestones:

- FY04—Identify candidate nuclear fuels for human and advanced robotic applications.
- FY05—Formulate a test plan for advanced nuclear fuels. Engage DOE to insure facilities are ready/refurbished for fuel development efforts.
- FY06–08—Begin development of high temperature candidate reactor fuels for human and advanced robotic applications.
- FY06–08—Begin development of surface power reactor for Lunar and Mars applications.

4) Advanced Nuclear Systems Concepts and Mission/Systems Analyses

Objective: Conduct mission and system analyses to identify human and advanced robotic applications that will benefit from or require Project Prometheus technologies, to identify gaps in current technology investments, and to guide future investments in advanced technologies.

Milestones:

- FY04–05—Complete missions studies to identify critical issues in piloted nuclear propulsion and nuclear surface power.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. ERNEST F. HOLLINGS TO HON. SEAN O'KEEFE

Recent NASA decisions related to using the Space Shuttle for future missions suggest that NASA now considers the vehicle to have inherently unsafe properties. This is not consistent with the views expressed by the *Columbia* Accident Investigation Board (CAIB) and contrary to the Committee's understanding.

Question 1. Does NASA now consider that some attributes of the vehicle or its operational regime are inherently unsafe?

Answer. As the loss of *Columbia* and her crew has reminded us, working in space is inherently risky. The CAIB recognized the risks associated with operating the Space Shuttle and made its recommendations consistent with the overriding objective of safety. NASA recognizes these risks and is working to mitigate them as best as possible through our Return to Flight effort, which is guided by the CAIB recommendations. Recent decisions on how to best utilize the Space Shuttle were made in light of NASA's intent to mitigate the risk associated with potential future missions.

Question 2. CAIB Chair Admiral Harold Gehman has stated that "Almost all the risk is concentrated in the front and back of the mission, where one goes on orbit makes little difference." How and why does NASA's view differ?

Answer. While dynamic loading on the Orbiter is greatest during launch and reentry, problems arising from component functional failures, system conditional events, and damage from external impacts can occur at any time during a Shuttle flight. NASA is committed to providing future crews with the tools necessary to mitigate risk, including the ability to check for potential damage to the Orbiter, to repair damage to the tiles or the Reinforce Carbon-Carbon (RCC) panels and to mount a rescue mission to return the astronauts safely to Earth. On the basis of risk, NASA has decided to fly Shuttle missions only to the International Space Station (ISS).

In the past, Space Shuttles have routinely docked with the ISS; the ISS crew is well trained in the Soyuz evacuation procedures. These represent the normal operations mode supported by extensive training, analysis and documentation. A rescue from the ISS, with multiple hatches, airlocks, and at least one other vehicle available (Soyuz), is much less complex and risky than that required by a stranded Space Shuttle being rescued by a second Space Shuttle.

In an emergency situation, the ISS is capable of providing a "safe haven" for a Shuttle crew of seven astronauts for up to ninety days. This window provides enough time to consider all options, determine the best course of action, take the time required to understand the cause of the failure and affect repairs, or send the appropriate rescue vehicle with the right equipment to bring the crew home.

No other location in space provides the same capabilities as the ISS. Missions to other destinations have significantly shorter stay times on orbit due to the limited stores of crew life support consumables available on the Orbiter. In response to a question by the *Columbia* Accident Investigation Board, NASA analyzed a hypothetical rescue mission between two Space Shuttles and found that the effort would have required many unproven techniques, such as emergency free-space crew transfer in space suits while performing Space Shuttle to Space Shuttle station-keeping. These major safety risks are not incurred during rescue from the ISS.

Question 3. How will the Shuttle's safety attributes be defined and captured for future vehicle and mission management?

Answer. The Shuttle's safety attributes are assessed by hazard analyses that are done by the prime contractor and approved by NASA's independent System Safety Review Panel. Hazard mitigating controls will be defined and/or re-verified for all catastrophic hazards prior to return to flight.

Question 4. For example, will this analysis be conducted as a risk analysis by NASA's Independent Technical Engineering Authority?

Answer. The analysis will be conducted by the prime contractor with functional oversight by matrix support resources provided by the NASA Safety and Mission Assurance (SMA) organizations at the various centers. The Shuttle Program's safety review panels are being transferred from the Program to the Center SMA organizations as a function that will be provided by the Center SMA organization in their independent technical authority (ITA) role. The SMA organization's safety review

panel will exert its formal approval authority for all hazard reports as a prerequisite for Program approval of same. Also acting independently from the control of the program, both the Center's engineering and safety and mission assurance organizations (acting in their independent technical authority roles) will be performing safety assessments, both process and technical, to assure the safety of decisions made by the program.

Question 5. What is NASA's current thinking about how Shuttle safety will be managed?

Answer. NASA has not finalized an approach to how Shuttle safety will be managed, and will not finalize an approach until the Stafford-Covey Return to Flight Task Group certifies that NASA's approach addresses the recommendations of the *Columbia* Accident Investigation Board. NASA's current approach is that the Associate Administrator for the Office of Space Flight and his direct reporting Deputy Associate Administrator (ISS & Space Shuttle) and his Program Manager for the Space Shuttle will remain responsible and accountable to the Administrator of NASA for the safety and mission success of the Shuttle within the limits of their technical authority. Toward that end, the Program Manager has established an SMA Office headed by an SMA Manager and assigned a few staff. This Program SMA Manager will integrate the activities of safety professionals that are assigned as direct matrix support to the program from resources that report directly to the Center's SMA Directors. This direct matrix support will enable the Program Manager to gather the right kinds of information that will assist him in making day-to-day decisions having any safety impact. The Center SMA Director will also employ resources that are not in a direct support role but in a role of independent assessment and review and approval of increased risk where hazards cannot be either eliminated or otherwise mitigated. This role is known as the independent technical authority role of the SMA Director and is a check and balance for the decisions on risk that are presented for Program Manager's decision.

These critical checks and balances at the Program level are further augmented by several independent services provided by the Associate Administrator for Safety and Mission Assurance. These services include the technical engineering assessments and testing that are provided by the NASA Engineering and Safety Center (NESC), an Office of Safety and Mission Assurance organization located at Langley Research Center and the process-oriented audits (known as process verifications) performed directly by the Office of Safety and Mission Assurance (OSMA) organization located at Headquarters.

In general, the Associate Administrator, Office of Safety and Mission Assurance oversees all the assurance activities that integrate to support safety, reliability and quality for all NASA programs. This includes the activities of the contractor, the NASA program managers, any matrix direct support to the program, the independent technical authority role of the SMA organizations, and the Agency policy for safety and mission success and audits to assure conformance to the policy.

Question 6. What is NASA's current projection of the probability of loss of Shuttle vehicle and crew? Which office at NASA is now responsible for that prediction and is review of this prediction a part of the evaluation being conducted by the Return-to-Flight Task Group?

Answer. The Space Shuttle Safety and Mission Assurance Office, based at the Johnson Space Center, has been tasked by the Space Shuttle program to conduct a probabilistic risk assessment (PRA) of this issue. This office is in the process of completing the PRA in the October/November 2004 timeframe. The PRA is currently under review by an independent peer review team. The Return-to-Flight Task Group will not review the PRA as part of its evaluation.

Question 7. The National Academy of Science's National Research Council has been asked to analyze NASA's decision not to fly the fourth Hubble Servicing Mission. How does NASA intend to use the academy's work?

Answer. NASA asked the National Research Council for assistance in "ensuring that we have fully considered all reasonable alternatives" in extending the operational lifetime of the Hubble Space Telescope. (Letter of Request Enclosure 1) We intend to use their world-renowned expertise in guiding our decision on the best method/methods available to extending the life of the Hubble Space Telescope, while keeping fully in line with all current safety guidelines.

Question 8. In its report and in subsequent public comments and testimony, the CAIB emphasized that there was a lack of sustained government commitment over the past decade to improve U.S. access to space. The CAIB addressed this concern about general U.S. space transportation needs as a matter separate from the agency need for a high priority mission.

Please describe how and if the new Space Exploration Vision will address the need for improved access for humans to low-Earth orbit.

Answer. The Vision for Space Exploration expands human presence *beyond* low-Earth orbit. A significant element of the architecture for human exploration is safe, reliable, and affordable access to space. NASA is currently developing transportation architectures and concepts of operations that will generate requirements for the Crew Exploration Vehicle (CEV) and its supporting elements including the launch vehicle(s).

Question 9. How much funding is contained in the run-out of NASA's FY 2005 budget request for new Advanced Space Transportation solutions other than those funds reserved for the Crew Exploration Vehicle (CEV)?

Answer. Specific funding for advanced space transportation activities is not yet identified. NASA is currently developing transportation architectures and concepts of operations that will generate requirements for the Crew Exploration Vehicle (CEV) and supporting elements for the launch vehicle(s).

Question 10. Please identify how NASA plans to support U.S. Advanced Space Transportation will benefit national security and the development of new commercial launch technology systems.

Answer. A strong space transportation capability is critical to meeting both national security and civil access to space objectives. The civil and national security communities often rely on common launch systems to assure access to space.

NASA is currently in the process of identifying the level 1 requirements for implementing the Nation's Vision for Space Exploration. These requirements are derived from architectural models under consideration for returning to the moon and the associated concepts of operation As NASA's requirements evolve, we anticipate that heavier launch capability and investments in key areas of space transportation technology may be required to implement the national Space Exploration Vision. The agency will solicit ideas and capabilities from industry (and from universities) to meet these still evolving requirements. In addition, NASA is working with the national security community to understand our respective requirements and pursue technology investments in a coordinated manner in space transportation that provides the Nation a more viable commercial space industrial base

The Vision for Space Exploration calls on NASA to "pursue commercial opportunities for providing transportation and other services (crew and cargo) supporting the International Space Station and exploration missions beyond low Earth orbit." NASA will pursue commercially available launch services and other potential commercial services to support the end-to-end concept of operations, consistent with specific mission requirements and space transportation guidelines.

Additionally, NASA will pursue opportunities for appropriate commercial technology transfers, through established licensing and other mechanisms, to foster the development of commercial launch systems that can further enhance the national security and industrial base.

Question 11. The President's Vision says we will return to the Moon sometime between 2015–2020. Why such a long window?

Answer. The 2015–2020 window for a human lunar exploration mission allows NASA to develop the requirements for returning to the Moon focused on the overall vision of a sustained, affordable exploration of Mars and beyond. The window also provides flexibility to incorporate critical precursor information from robotic missions to the moon, thus enabling an efficient approach to human missions.

Question 12. What are the major elements that keep us from arriving on the earlier date?

Answer. NASA is committed to realizing the Vision for Space Exploration without a significant increase in NASA's budget. NASA will develop the capability for human exploration within the budget through a spiral development approach that develops sound requirements within known mission objectives and evolves the requirements for future mission objectives. This spiral process of requirements and the development of capabilities will form the foundation for human missions to the Moon that support sustainable, science driven exploration of Mars and beyond.

Question 13. The President's Vision says we will conduct missions on the Lunar Surface for extended periods after we have arrived. Could you describe what some of those activities might be? Will our emphasis be science or mineral exploitation of the Moon?

Answer. In its Vision for Space Exploration dated February 2004, NASA has stated a basic requirement to "conduct a series of robotic missions to the Moon to prepare for and support future human exploration activities." Another basic requirement states that NASA will conduct human lunar expeditions "to further science, and to develop and test new exploration approaches, technologies, and systems, in-

cluding the use of lunar and other space resources to support sustained human space exploration to Mars and other destinations." Activities on the lunar surface will be defined within the requirements for exploration missions and as part of the concept of operations.

Question 14. Are there international treaties that stand in our way if we pursue mineral exploitation?

Answer. The primary purpose of going to the Moon in the Vision for Space Exploration is to use lunar activities as a stepping stone to Mars and other destinations, testing technologies and concepts for use beyond the Moon. In addition, lunar exploration activities will be used to further science and to begin the extension of human presence across the solar system. Exploitation of lunar resources, if such resources are discovered and recoverable, may raise legal issues that the Nation may need to address at an appropriate time.

Question 15. Is it implicit in NASA's proposals that the President's new Space Exploration Vision will result in safer travel and operations in space? Are travel to and operations at the Moon safer than entering low-Earth orbit? Please describe the concept of operations that will be used to mitigate the risks inherent to low Earth orbit staging and deep space travel and operation.

Answer. In its Vision for Space Exploration dated February 2004, NASA has stated a basic requirement to safely "implement a, sustained, and affordable robotic and human program to explore and extend the human presence across the solar system and beyond." One basic objective to accomplish safe operations is to separate crew from cargo for launches of exploration missions to the maximum extent practical. This is a safer approach to crew transport. Safety will be incorporated within all phases of the exploration missions, beginning with the development of sound requirements. This process integrates only mature, demonstrated systems into the design of each spiral. Future spirals will be supported by a strong, ongoing technology maturation process to increase capability and improve safety and affordability.

Question 16. If future access to space will rely on commercial launch systems, what levels of reliability will need to be met to significantly increase crew safety? Please describe the types of efforts that will be required to achieve these heightened levels of reliability and safety.

Answer. Current commercial launch systems will be assessed against the NASA Human-Rating Requirements and Guidelines for Space Flight Systems (NPR 8705.2) and must comply with specific aerospace design standards, design criteria for human space flight, flight test, crew survival systems, and safety and reliability processes.

Question 17. It appears that the U.S. intends to rely on the Russian Soyuz vehicle for crew transfer and return for a period of years. How and why is that a safer approach than simply continuing to use the Space Shuttle to meet these requirements?

Answer. NASA has significant interaction with the Russian Federal Space Agency (FKA) and the vehicle manufacturer (RSC-Energia) regarding safety of the Soyuz vehicles. On the basis of this interaction and the historical record of Soyuz and Soyuz-derived vehicle performance, NASA is confident that the Soyuz is among the safest spacecraft ever flown.

Each Soyuz spacecraft is operated within the design, certification and experience of our Russian partners. Under the provisions of the Memorandum of Understanding (MOU) between NASA and Rosaviakosmos (now FKA) concerning cooperation on the International Space Station (Article 10.2), FKA is responsible for meeting or exceeding the overall Space Station safety and mission assurance requirements and plans established by NASA and the Partnership. Article 10.2 of the MOU states: "In support of NASA's overall responsibilities to assure safety and mission assurance, FKA will be responsible for certifying that the Russian Segment and the FKA-provided elements, including cargo, are safe and ready for operation using jointly agreed documentation and processes." The Soyuz has been certified under these conditions.

In addition, each Soyuz mission undergoes a number of joint Russian and U.S. expert reviews. Prior to each mission the U.S.-Russian Stafford-Anfimov Joint Commission conducts an in-depth joint assessment of the operational readiness of the mission. The resulting report is one of the inputs to the detailed NASA technical reviews that culminate in a Flight Readiness Review for each mission.

The certification under the MOU, our technical and safety history with Soyuz vehicles and current processes for joint Station operations combine to ensure the safety of future use of Soyuz.

Question 18. Why was the Orbital Space Plane cancelled? Why couldn't the CEV have been accomplished through spiral development of the Orbital Space Plane,

thereby resolving both immediate and long-term NASA needs for crewed space transportation?

Answer. The spiral development process is initiated with the development of requirements that are consistent with the concept of operations defined by the known mission. The Orbital Space Plane requirements were not developed to support the Vision for Space Exploration, but for a significantly different purpose.

Question 19. Will the CEV be used as the Crew Rescue Vehicle for Space Station? If not, is that mission going to be accomplished by the Russians; and have the Russians agreed to provide that capability indefinitely?

Answer. The design of the CEV will be driven by the needs of the future human exploration missions, but it might also supplement potential commercial and international partner transport systems to the Space Station. Requirements for the CEV are in development, with a draft release planned for September.

Question 20. Materials submitted by NASA as back-up to the "sand chart" indicate that spending on NASA Human Exploration Missions will not begin until FY 2011, several years after the current change in NASA's direction. Given the importance of responding to the Nation's urgent call for redirecting Human Space Flight, this seems like a significant period of delay in achieving renewal. Please describe why NASA chose to maintain the full, final configuration of the International Space Station (ISS).

Are there any additional de-scope options for ISS assembly that would contribute additional funds to an early start of new Human Exploration Missions?

Answer. A final decision on the ISS configuration has not yet been established. NASA is currently involved in detailed technical discussions with its international partners to establish the ISS configuration. Guiding principles for NASA in the ongoing technical discussions with the partners are the new U.S. Vision for Space Exploration, which states that the U.S. will complete assembly of the ISS, conduct ISS activities in a manner consistent with U.S. obligations contained in the agreements between the U.S. and other ISS partners and that NASA will focus its research activities on ISS to support U.S. exploration goals. It is anticipated that a proposed ISS configuration which meets each of these principles will be presented to the ISS Heads of Agency for approval in late July. Given the maturity of U.S. flight hardware developed for ISS it is unlikely that any significant savings would be realized for exploration by a descoping of planned U.S. contributions to ISS.

All of the ISS Partners recognize that there are implications for the ISS program as a result of the temporary grounding of the Space Shuttle fleet and the announcement of the Vision for Space Exploration. NASA has been and continues to be engaged in a discussion of these issues with our Partners. There is much detailed work yet to be done at the technical coordination level to ascertain the impacts of these changes on the ISS Program. Such discussions have included concerns about extended lifetimes for components now on-orbit, ensuring a proper return from modules that will be delivered later in the assembly sequence, and determining the final on-orbit configuration of the ISS for utilization of the ISS through at least 2016.

As agreed during the December 11, 2003 Multilateral Coordination Board (MCB) telecon, the MCB met in Washington on February 12, 2004. This was the first meeting of the MCB after the announcement of the Vision for Space Exploration. NASA used this opportunity to brief the ISS Partnership on implications of the Vision for the ISS program and the methods by which the Vision will be implemented. The MCB agreed that the Vision for Space Exploration helped to satisfactorily resolve some of the issues under discussion about the ISS configuration, but the planned retirement of the Shuttle raised a number of new questions. To address these issues in a comprehensive manner, the MCB assigned a multilateral team to define an ISS configuration and implementation framework. The MCB received a status report on this work at their late-June meeting. The Partners are expecting to hold an ISS Heads of Agency meeting in late July frame.

Question 21. Please explain why additional Human Space Flight economies needed to most quickly achieve renewal is not an option.

Answer. Consistent with the Vision for Space Exploration, NASA is committed to returning the Space Shuttle to safe flight as soon as practical, based on the recommendations of the *Columbia* Accident Investigation Board. The Space Shuttle will be utilized to complete assembly of the International Space Station (ISS), planned for the end of the decade, at which point the Shuttle fleet will be retired.

In the broad context of the Vision, the ISS will be utilized through at least 2016. It will serve as a test bed for the scientific and technical research and development needed to fulfill the objectives of the Vision. NASA will continue the operation and maintenance of the ISS so long as it benefits the long-term future of human space flight. The ISS is an integral part of the stepping-stone approach to the exploration

goals articulated by President Bush. The future of the ISS will be fully coordinated with our International Partners in accordance with our ISS agreements.

Pending Congressional approval, spending on Human Exploration Missions will begin well before 2011. Significant funding for the future Crew Exploration Vehicle, including design studies and related technology development, is included in NASA's FY 2005 Budget request. A total of nearly $1.8 billion in FY 2005 funds is requested for the Exploration Systems Enterprise (beginning on 8/1/04, this activity will be referred to as the Exploration Systems Directorate), which has a lead role in implementing the Vision for Space Exploration.

NASA is responsibly budgeting the taxpayer's money in the near-term and planning for the longer-term, in order to achieve the Vision for Space Exploration as efficiently and effectively as possible. Diverting the Space Flight funding prior to safely returning the Space Shuttle to flight and completing assembly of the ISS would impact NASA's deliberate stepping-stone approach to successfully achieving the Vision for Space Exploration.

Question 22. At any time during the past year, did discussions between the U.S. and the International Partners address possible de-scoping of the ISS assembly configuration? If so, please describe the options presented and discussed, and the response of the partners to those options.

Answer. The Vision for Space Exploration states that NASA will complete assembly of the ISS, including the U.S. components that support U.S. space exploration goals and those provided by foreign partners, planned for the end of the decade. Completing assembly of the ISS by the end of the decade may require changes to the final configuration of the ISS. It is not clear whether those configuration changes might affect international components. The Vision for Space Exploration directs NASA to conduct ISS activities in a manner consistent with U.S. obligations contained in the agreements between the United States and other ISS partners. Although NASA has on-going discussions with the partners regarding ISS configurations, NASA has not to date discussed de-scoping the ISS in partner meetings.

Question 23. If the President's time-line is followed, there is likely to be a significant hiatus between the last Shuttle flight and the first flight of the new CEV. During the same period, it is likely that legacy NASA and industry aerospace workers will have retired or have been laid off from current operations assignments for a period of years. What is NASA's plan to ensure that when a new NASA and industry operations workforce is needed to operate CEV, they will be available?

Answer. To support the Vision for Space Exploration, an assessment of capabilities throughout NASA is being conducted. The objective is to determine how these capabilities map to the skill requirements for the Vision. A trained and skilled workforce, on both the NASA and industry side, is important to ensuring the success of operating the CEV. The Agency will ensure that the necessary skills for operating the CEV are in place when required.

Question 24. By terminating the Space Shuttle in 2010, NASA can avoid the cost of re-certification, a requirement levied on NASA by the CAIB. However, it is possible that NASA may need to continue using the Space Shuttle beyond that date in order to complete assembly of the International Space Station. NASA has advised the Committee that something less than a full structural and mechanical recertification and test of the Space Shuttle may be adequate to meet the CAIB recommendation or to operate the Shuttle after 2010. What does NASA estimate the cost of Shuttle re-certification to be?

Please describe the "lesser standard" that might be substituted for the recommendation of the CAIB.

Answer. NASA is currently reassessing the ISS assembly sequence to ensure that the Shuttle can be safely retired following assembly of the International Space Station. To prepare for the contingency that the Shuttle may need to operate beyond 2010, NASA is reassessing the need to recertify Space Shuttle systems, subsystems, or components consistent with the Vision for Space Exploration and in line with the recommendations of the *Columbia* Accident Investigation Board. The technical work required to determine what recertification would entail will continue into summer 2004. Once the technical definition of the recertification tasks is completed, cost estimates on the items we may need to recertify will be developed and made available for discussion.

Question 25. Please describe the process NASA used to (1) assign priorities to enterprises and programs and (2) select missions to be deferred or cancelled. Why were Earth Science, High-Energy and Relativity Physics and Solar Physics deemphasized in NASA's current budget request?

Answer. The NASA budget process evaluated and selected programs with respect to four key principles:

Compelling—The programs fully support the Vision for U.S. Space Exploration or provide for ongoing NASA mission priorities such as Aeronautics and Earth Science in accordance with the NASA Strategic Plan.

Affordable—The programs are part of a budget that is fiscally responsible and consistent with the Administration's goal of cutting the Federal deficit in half within the next 5 years.

Achievable—The programs will *not* require large balloon payments by future Congresses and Administrations.

Focused—The Vision for Space Exploration provides the needed compass with which to evaluate our programs and make the required tough decisions.

Earth science and space physics remain priorities for NASA. Although some new projects were postponed, NASA's 5-year budget request for Earth Science is about $1.4 billion annually, representing a significant Administration priority. NASA remains the largest Federal contributor to the Climate Change Research Initiative. Approximately 40 percent of the FY 2005 Earth Science budget will go towards research on data from 80 sensors supported by NASA's 18 Earth-observing satellites. NPOESS Preparatory Project (NPP), used to harness NASA satellite data for global climate change observations, increased funding by 36 percent for FY 2005. The Orbiting Carbon Observatory (OCO), which relies on space-based platforms to measure atmospheric levels of carbon dioxide that generate data for the enforcement of emissions standards, was increased by 37 percent in FY 2005.

NASA's budget for Structure and Evolution of the Universe averages $400 million annually over the next 5 years. The budget for Sun-Earth Connection ramps up to $1 billion over the next 5 years. While some previously planned work has been deferred, these activities remain significant strategic objectives of the Agency.

Question 26. If NASA were directed to assume sustained, level funding from FY 2004 to FY 2005, including Congressional directed funding, please describe how existing and new NASA programs would be affected.

Answer. A freeze at the FY 2004 appropriation level would jeopardize many important activities:

- *Level funding would reduce Space Shuttle by $374 million,* jeopardizing efforts to safely return to flight and continue assembly and operations of the International Space Station,
- *Level funding would reduce Space Station by $365 million,* eliminating new funding for crew & cargo services and draining needed reserves,
- *Level funding would reduce Exploration Systems by $136 million,* slowing or eliminating investments in key technologies needed to support exploration of the Solar System and beyond,

Without the requested increase for FY 2005, NASA will still need to provide increased funding to meet priorities for return to flight of the Space Shuttle and assembly of the International Space Station. *This will require substantial offsets from other ongoing activities as funding sources.* Inclusion of Congressionally directed funding from the FY 2004 appropriation would exacerbate this situation, and require additional offsets from other ongoing activities.

Question 27. The CAIB recommended there be a "detailed plan for defining, establishing, transitioning, and implementing an independent Technical Engineering Authority" prior to the Shuttle's return-to-flight. When does NASA anticipate that plan will be available for external review?

Answer. NASA has expanded the *Columbia* Accident Investigation Board (CAIB) recommendation 7.5–1 on "independent technical engineering authority (ITEA)" to include both the engineering authority and the safety and mission assurance authority into one broader authority and called the expanded authority the independent technical authority (ITA). We anticipate that the plan being developed for implementing an independent technical authority to be ready for additional external review sometime in the summer of 2004. The plan will be provided first to the Stafford-Covey Return to Flight Task Group for assessment and advice to NASA prior to broader external review.

Question 28. Please identify the amount of funding for this new Authority contained in the current budget request and FY 2004 Operating Plan.

Answer. There is no special funding consideration for the ITA in the FY 2004 Operating Plan as the concept will first be addressed and funded as a directed service pool beginning in FY 2005 (October 1, 2004). The funding level for the service pool is at the present time yet to be determined.

Question 29. The Committee requested a breakout of NASA funding by Center and Budget Line Item for FY 2005. According to NASA, that information is not available due to new budgeting procedures premised on the "One NASA" concept. Why is the Integrated Financial Management Program (IFMP) unable to provide this type of information? Will IFMP ever be able to provide this type of information? If so, when?

Answer. For budgetary data reporting, the agency-wide IFMP's Budget Formulation module (BF) is still on schedule for initial deployment in the first quarter of FY 2005. Reports by Center and BLI, reflecting our new budgetary procedures will be available shortly afterwards (once the BF module is "populated" with the budgetary data from all Centers and programs).

For execution data reporting, the conversion to Full Cost accounting and reporting which came into effect in October 2003 (for FY 2004) has required several policy changes and updates related to the detailed identification, treatment and allocation of indirect cost items such as General and Administrative (G&A) expenses and Service Pools allocations. Those changes had to be reflected in the new reports generated out of the IFMP's Core Financials module. Definition and production of those report formats started as soon as our policy was set in late September 2003 and several reports are now produced reflecting those policies.

Question 30. Please describe the schedule for continued roll-out of the IFMP, including an estimated date of completion for all core modules and Center core and project management systems. Also describe the agency's plans for implementation of electronic contractor cost and performance management reports for all NASA programs.

Answer. See Enclosure 2 for IFMP rollout schedule including an estimated date of completion for all core modules and Center core and project management systems. Center rollout for Core Financials module took place as scheduled and on budget during the fourth quarter of FY 2003. Starting with the first quarter of FY 2004, all Centers were operating on the Core Financials module as planned. As customary in this type of large deployment, a significant amount of post-implementation historical data cleanup activities were involved in the "stabilization" period. This data integrity task, as anticipated, is still on-going as part of our forthcoming FY 2004 audit preparation effort.

The IFMP's Integrated Asset Management project includes the development and implementation of electronic cost and performance management metrics by 2007 including Earned Value Management functionality.

ENCLOSURE 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION HEADQUARTERS
Washington, DC, March 17, 2004

Reply to Attn of:

Dr. Bruce Alberts,
Office of the Chairman,
National Research Council,
Washington, DC.

Dear Dr. Alberts:

As you know, the mission of the Hubble Space Telescope has been one of the most productive scientific undertakings of all time. One of our principal concerns today is finding the best way to extend the lifetime of this national asset. I would like to ask for the assistance of the National Research Council in ensuring that we have fully considered all reasonable alternatives to this objective. The assessment should address the following issues:

1. Assess the viability of a Shuttle servicing mission to the Hubble that satisfies all CAIB recommendations, as well as any additional ones identified by NASA's ongoing Return to Flight activities. Estimate to the best extent possible the time and resources needed to overcome any unique technical or safety issues associated with Hubble servicing that are required to meet the recommendations of CAIB, as well as ongoing Stafford-Covey RTF activities. Enclosed is a white paper describing these activities.
2. Survey other engineering options available for Hubble servicing that could extend the lifetime of the Hubble. This would include both robotic intervention on-orbit and optimization of ground operations.

3. Assess the response of the spacecraft to likely major component failures, and the resulting impact on servicing feasibility, lost science, and the ability to safely dispose of Hubble at the end of its service life.
4. Based upon the results of assessments carried out in paragraphs 1 through 3, assess the entire gain/risk equation of whether extension of the Hubble service life is worth the risks involved, including a Shuttle servicing mission only if such a mission is found viable in satisfying all the recommendations of the CAIB, as well as ongoing Stafford-Covey RTF activities.

We presently have a study underway at the Goddard Space Flight Center, based in part on a public Request for Information, evaluating means to extend the Hubble's life; we will be pleased to share the results of this activity with you when they become available in about a month.

I would be happy to discuss the scope and schedule of this study with you at your earliest convenience.

Cordially,

EDWARD J. WEILER,
Associate Administrator for Space Science.

Enclosure

cc:
A/Mr. S. O'Keefe
AA/Mr. J. Schumacher
AD/Mr. F. Gregory
AD–2/Mr. G. Martin
ADT/Dr. Greenfield
AS/Dr. J. Grunsfeld
GSFC/100.0/Mr. A. Diaz
Space Studies Board/Mr. J. Alexander

CANCELLATION OF THE FIFTH (SM–4) HUBBLE SERVICING MISSION

Executive Summary

The Hubble Space Telescope (HST) was originally launched aboard the Space Shuttle in 1990, with an as designed mission lifetime of 15 years. Since then the telescope has been serviced or upgraded four times, each requiring a very complex, dedicated Space Shuttle mission and unique HST servicing support equipment. Even before its repair mission in 1993, the HST had generated significant scientific discoveries. The science return from HST has already vastly exceeded the original expectations.

NASA plans continued operation of the HST until it can no longer support scientific investigations anticipated to occur in the 2007–2008 time frame. The telescope's life may, in fact, be extended if NASA is successful in employing operational techniques to preserve battery and gyroscope functions. Meanwhile, NASA is aggressively investigating innovative ways to extend the science lifetime of the HST for as long as possible, including robotic servicing to provide extension of power storage. Current plans are to safely deorbit the HST by a robotic spacecraft by approximately 2013.

Although the HST deployment mission and four subsequent servicing missions were successfully conducted, the Columbia tragedy underscored the inherent risk in each and every Space Shuttle mission and reinforced the need for increased ability to deal with ail potential contingencies, particularly catastrophic damage to the Orbiter's thermal protection system (TPS).

Without the benefit of docking at the ISS many new tools, processes, and techniques would be required for inspection and possible repair of the TPS. More significant would be the requirement to dedicate two Space Shuttles to the mission to ensure astronaut safety. In the event of a significant problem with no safe haven for the astronauts to wait as in ISS missions, a second Shuttle would have to be launched and employ untried and uncertified techniques to perform a rescue. Hence, a Shuttle based HST servicing mission presents known additional risks, and offers few options to respond to serious problems in orbit.

Recognizing the increased risks involved in all Shuttle flights following the tragic loss of the Columbia and crew NASA elected to reduce its planned Shuttle manifest to only missions to the International Space Station (ISS). The decision was also made, on the basis of risk, to not pursue a final servicing mission to the HST, but instead to investigate other options to extend the life of the Hubble.

Columbia Accident Investigation Board Findings and Impact on Future Missions

The Columbia Accident Investigation Board presented NASA with 29 recommendations, 15 of which were required to be completed before the Space Shuttle could return to flight. Highlights of these flight-critical recommendations included elimination of damaging insulation shedding from the external tank—the cause of the Columbia tragedy—ascent imaging, on-orbit inspection, and thermal protection system tile and Orbiter leading edge repair. NASA will satisfy all of these recommendations before it launches STS–114, the next Shuttle mission. The Board stressed that the Space Shuttle is still a developmental vehicle and that risk and risk mitigation must be treated accordingly. NASA's original vision was to fly the Shuttle to mid-decade or 2020 for a total of 75–80 more flights. NASA fully accepts the Board's recommendation and balancing mission criticality against possible loss of crew and vehicle, consciously decided to retire the Space Shuttle after the completion of the International Space Station (ISS), recognizing that the best risk mitigation strategy is to fly less.

In addition, NASA realizes that a "safe haven" in space capability is required. This "safe haven" capability goes beyond compliance with the Columbia Accident Investigation Board recommendations and is designed to increase crew safety during the remaining Space Shuttle missions. Should damage occur to the Shuttle thermal protection system that cannot be repaired and that would preclude safe reentry, the crew will be able to shelter at the ISS until another vehicle can be readied for rescue. Agency policy will require each Space Shuttle mission to have backup rescue capability. "Safe haven" is the ultimate recognition that, while NASA will make the Space Shuttle as safe as possible, the Columbia tragedy has taught us that there are still significant risks inherent in Space Shuttle launch, orbit operation, and reentry.

Unique Requirements and Increased Risk in the Hubble Servicing Mission

Whereas tools, techniques, and procedures would be similar on each ISS mission; *e.g.,* inspection, thermal protection system repair, safe haven readiness, and rescue scenario, an HST servicing mission would have unique requirements, both on-orbit and in ground processing. Options for dealing with an on-orbit emergency are reduced and decisions for reacting to any emergency would have to be made quickly. These two considerations, and the attendant schedule pressure on the flight crews and support teams, add considerable additional risk.

Lack of Significant Safe Haven

The areas of additional risk relate to the ability to provide "safe haven" while inspection, repair and potential rescue are undertaken, and to the procedures for inspection and repair themselves. It has been projected that a typical Space Shuttle flight crew of seven astronauts could stay aboard the ISS for up to ninety days, if warranted, due to an emergency situation on the Space Shuttle. This safe haven capability allows the flight crew and ground teams to consider all options, determine the best course of action, take the time required to understand the cause of the failure and affect repairs, or send the appropriate rescue vehicle with the right equipment to bring the crew home. Clearly, rushing this process would introduce considerable new risk and in the worse case result in the loss of another vehicle.

In the case of a Hubble servicing mission, the amount of stay time on orbit is significantly shorter due the limited stores of cryogenic oxygen on the Orbiter. Therefore, other measures would be required. Specifically, a second Space Shuttle on an adjacent launch pad would have to be specially prepared, uniquely configured to launch expeditiously if required to perform a rescue mission. This scenario raises several concerns, addressed in the paragraphs below.

Unprecedented Double Workload for Ground Launch and Processing Teams

Two vehicles would be processed for essentially the same launch date. Any processing delays to one vehicle would require a delay in the second vehicle. The launch countdown for the second launch would begin before the actual launch of the first vehicle. This short time period for assessment is a serious concern—it would require a highly complex process to be carried out in parallel, and it would not permit through assessment by the launch team, the flight control team, and the flight crew.

No Changes to Cargo or Vehicle Feasible

Because of the very short time-frame between the launch of the first vehicle and the requirement for a rescue flight, no significant changes could reasonably be made to the second vehicle or the cargo. This means that it would not be feasible to change the cargo on the second Space Shuttle, to affect a repair to the first Shuttle, add additional rescue hardware, or make vehicle modifications to avoid whatever

situation caused the need for a rescue attempt in the first place. Not having sufficient time to make the appropriate changes to the rescue vehicle or the cargo could add significant risk to the rescue flight crew, or to crew transfer. The whole process would be under acute schedule pressure and undoubtedly many safety and operations waivers would be required.

Rescue Mission

Space Shuttles routinely dock with the ISS; Soyuz evacuation procedures are well trained. These represent the normal operations mode today supported by extensive training, analysis and documentation. A rescue from the ISS, with multiple hatches, airlocks, and at least one other vehicle available (Soyuz), is much less complex and risky than that required by a stranded Space Shuttle being rescued by a second Space Shuttle.

In response to a question by the Columbia Accident Investigation Board, NASA analyzed a hypothetical rescue mission between two Space Shuttles and found that the effort would have required many unproven techniques, such as emergency free-space crew transfer in space suits while performing Space Shuttle to Space Shuttle station-keeping while traveling 17,500 mile per hour above the earth. These major safety risks are not incurred during rescue from the ISS.

The Survey (expanded inspection requirements) and Thermal Protection System Repair

The current inspection method for acreage tile, gear door seals, and the eleven cove is to photograph these areas from the ISS during rendezvous. To support an HST servicing mission, NASA would have to develop a new method for inspecting these critical areas using an Orbiter boom. Unvalidated autonomous boom operations represent an unknown risk. NASA's current planned TPS repair method for an ISS-based repair uses the ISS robotic arm to stabilize an EVA crew person over the worksite. These assets are not available for an HST servicing mission, so NASA would have to develop a single-use alternate method for stabilizing the crewmember. This method would have to provide greater stability than the current ISS option under development to protect both the crewmember and the other TPS areas from additional damage. Such a concept represents challenging undertaking, which could take months or years to develop in order to meet safety and mission assurance standards/requirements.

Return to Flight and ISS U.S. Core Complete Timeline

In the process of addressing the Columbia Accident Investigation Board recommendations and implementing additional improvements to achieve the safest flight possible, NASA has uncovered a number of problems that had previously gone undetected. The removal and replacement of unsafe hardware has deferred Space Shuttle launch milestones. NASA projects the first opportunity for a Space Shuttle launch to the ISS to be in March 2005. Eight flights are scheduled to meet our international commitments, the assembly of the U.S. core segments of the ISS. Given the ISS assembly schedule, the earliest NASA could launch a servicing mission to the HST, based on requirements for daylight launch to fully assess ascent conditions by imagery and thermal constraints when docked to ISS, would be Spring 2007.

Based on the evaluation of the engineering data on the HST, the lifetime of the Observatory on orbit is ultimately limited by battery life, which may extend in to the 2007–2008 timeframe. Scientific operations are limited by gyroscope lifetime that is more difficult to predict. If all of the NASA effort is concentrated on a Shuttle servicing mission, every step in the process must be successful with no allowance for schedule slips. Before launch all of the recommendations of the Columbia Accident Investigation Board must be met. The launch conditions must be perfect, and all tailored HST mission unique components must be in place with very tight schedule constraints. If any of the many elements do not develop as planned, the telescope may cease operations before a successful mission could be mounted.

Hubble Space Telescope's Scientific Legacy

Not since Galileo turned his telescope towards the heavens in 1610 has any event so changed our understanding of the universe as the deployment of the Hubble Space Telescope. From its orbit above Earth's atmosphere, the HST is free from the atmospheric turbulence that all ground-based telescopes must contend. Thus, HST has been able to return images of astounding clarity and sensitivity. HST imaging and spectroscopy have resulted in remarkable scientific achievement, including the determination of the changing rate of expansion of the universe and detailed studies of forming galaxies, black holes, galaxy hosts of gamma-ray bursts and quasars, active galactic nuclei, protostars, planetary atmospheres, and the interstellar and

intergalactic medium. Scientific results have significantly surpassed original expectations. By 2005, the HST will have fulfilled every one of its scientific objectives and top-lever technical requirements. Moreover, the Hubble will continue to collect observations for several more years. Even after the HST is no longer in service, the rich archive of HST data (already more than 100,000 observations of 20,000 unique targets) will continue to provide new discoveries for the years to come, with full support by NASA for both archive operations and research grants.

Future Plans for Hubble Space Telescope and Astronomy

Astronomy is a critical part of the NASA's exploration initiative. NASA is aggressively investigating innovative ways to extend the science lifetime of the HST for as long as possible, including a possible robotic servicing option. We are receiving several responses to our recently released Request For Information (RFI) on HST End of Mission Alternatives soliciting concepts for robotically-provided battery power extension. Indeed, this option appears to have greater likelihood of success than the possibility of accomplishing all the recommendations of the Board in time for a success Hubble servicing mission.

HST is not NASA's only portal to the stars. It is one of many telescopes used by astronomers to study the .universe using various apertures and wavelength bands. Hubble, primarily used for observations of visible light, is one of the four orbital "Great Observatories" designed for use across the spectrum. The other three include the Compton Gamma-Ray Observatory (1991–2000), the Chandra X-Ray Observatory, and the infrared Spitzer Space Telescope. In the years since Hubble was launched with its 2.4-meter aperture, many new ground-based telescopes have been built with larger apertures that enable observations with increasingly higher angular resolution, though subject to the blurring effects of Earth's atmosphere.

The James Webb Space Telescope (JWST) program has been strengthened to assure a 2011 launch date. Once on orbit, this advanced technology infrared telescope will provide insight into the a region of the spectrum where we will be able, like never before, to view the formation of the earliest galaxies. The JWST will build on the successful science of the Hubble via the most advanced instrumentation and a larger 6.5 meter aperture.

The following table lists larger optical telescopes now or soon to be available. along with Hubble and also several examples of large telescopes available or in development for observations at other wavelengths.

Examples of Large Telescope Facilities Available or In Development

Radio/MM	Infrared	Optical +IR (aperture, meters)	Ultraviolet	X-Ray	Gamma Ray
VLA	Spitzer	SALT (11.0)	HST	Chandra	GLAST
GBI	SOFIA	Keck I, II (10.0)	GALEX	XTE	SWIFT
ALMA	JWST	Hobby-Eberly (9.2)		XMM-Newton	
Arecibo	HST	LBT (8.4 x 2)		Astro-E2	
FCRAO		Subaru (8.3)		SWIFT	
VLBA		VLT {8.2 x 3)			
CSO		Gemini (N & S) (8.1)			
		HST (2.4)			

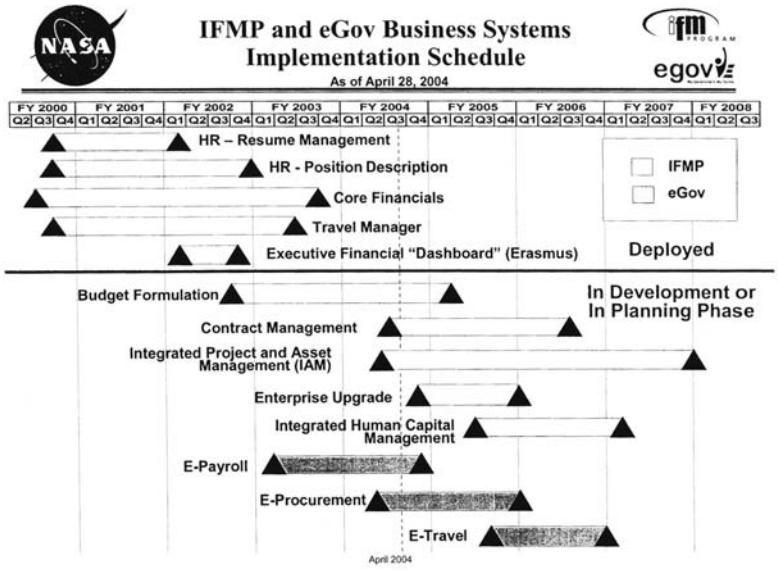
The HST program has provided a significant amount of funding support for U.S. astronomers; in fact, it is currently providing approximately 20 percent of all direct grant support. After HST observations have ceased, NASA plans to continue to support ongoing grants and to offer new grant support for HST archival research until a similar grant program is in place for the upcoming James Webb Space Telescope program.

This will ensure stability to the research community and full use of the rich HST data archive throughout this period of transition.

Conclusion

The cancellation of HST-SM4 was a difficult decision. HST is producing world-class science. However, NASA cannot justify the additional risk that such a unique mission would entail, based on what must be done to assure greatest protection to the crew. It is increasingly apparent that our choice is to either fully comply with the Columbia Accident Investigation Board report *or* conduct the servicing mission, but not both. We must be responsible on all future flights and be fully compliant. NASA will continue to aggressively pursue options to extend the science lifetime of the Hubble by means other than Shuttle servicing. NASA will continue to be a major supporter of astronomy in the future as the Agency continues to explore the universe.

ENCLOSURE 2


IFMP and eGov Business Systems
Implementation Schedule
As of April 28, 2004
egov
FY 2000
FY 2001
FY 2002
FY 2003
FY 2004
FY 2005
FY 2006
FY 2007
FY 2008
HR – Resume Management
HR - Position Description
Core Financials
Travel Manager
Executive Financial "Dashboard" (Erasmus)
IFMP
eGov
Deployed
Budget Formulation
Contract Management
Integrated Project and Asset Management (IAM)
Enterprise Upgrade
Integrated Human Capital Management
E-Payroll
E-Procurement
E-Travel
In Development or In Planning Phase
April 2004

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